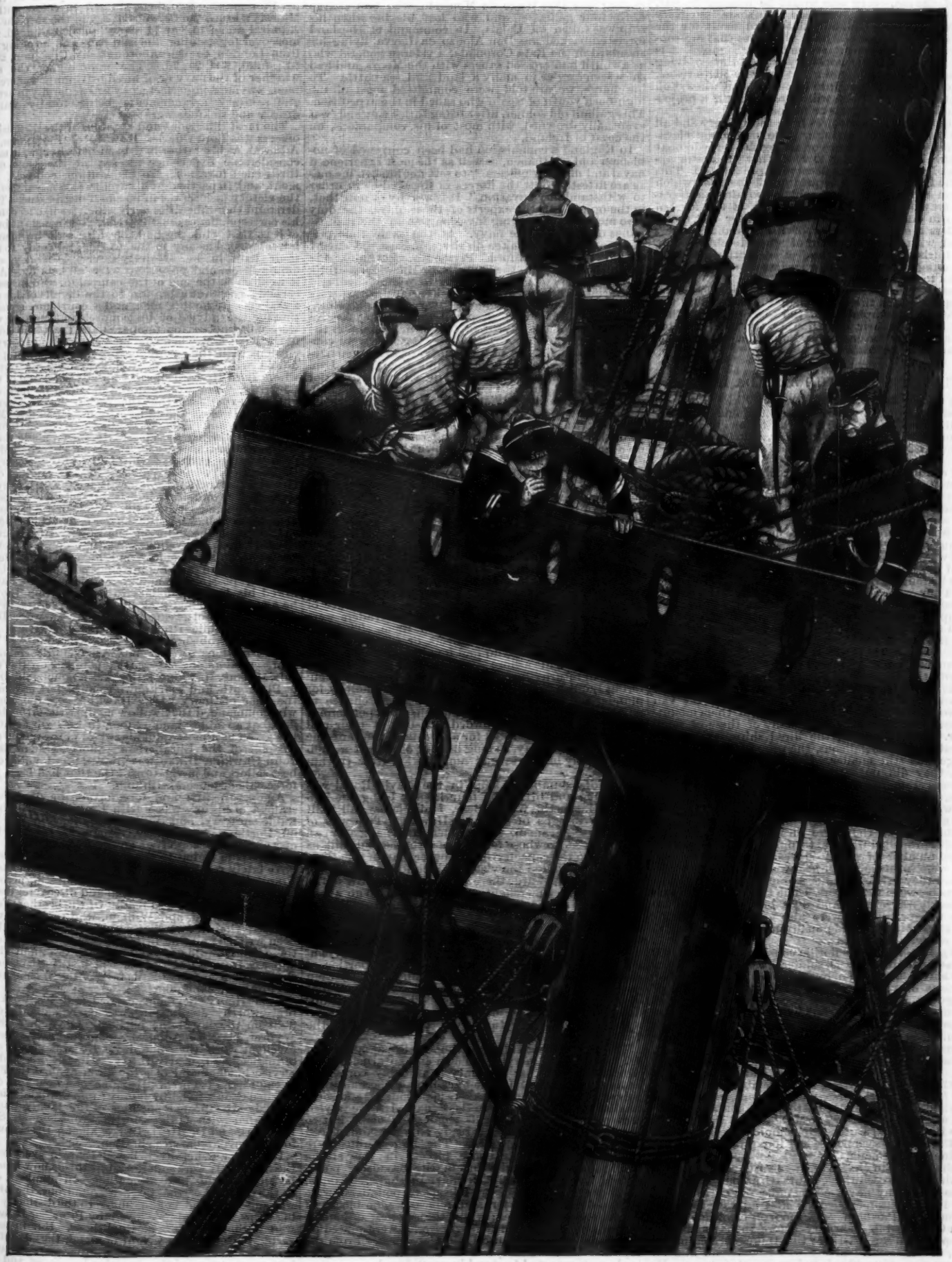
SCIENTIFIC AMERICAN
No. SUPPLEMENT 660

Scientific American Supplement, Vol. XXVI., No. 660.
Scientific American, established 1845.

NEW YORK, AUGUST 25, 1888.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



MANEUVERS OF THE FRENCH MEDITERRANEAN SQUADRON.

THE FRENCH MEDITERRANEAN SQUADRON.

THE maneuvers of the squadron which have just taken place in the Mediterranean have again attracted attention to our navy and particularly to the experiments that have the use of the torpedo as a basis.

Mr. Bourgain's sketch renders very accurately one of the phases of this fiery contest between the torpedo boat and the giant which it is attacking—the ironclad.

As well known, the torpedo boat sacrifices everything to speed. Built, to this intent, of relatively thin plate, it is provided with a powerful engine which renders it swifter than the swiftest of ironclads. It runs, almost invisible, between waves that often almost entirely submerge it, ready, when within 200 or 400 yards of the enemy, to launch its terrible weapon, the wound from which is often fatal. Bold, in its small dimensions, it presents itself without defense before its iron-sided adversary, and receives its blows without reply, even though it should perish from them.

On board the ironclad every one is astir. Before a giant of the sea, every one would be impassible, but, before this "microbe," every one is anxious. So every sailor has become a look-out, and it is difficult for the "invisible" to escape all those lynx eyes that are constantly scanning the sea. It has been recognized, it is within range! All the musketry and all the revolving guns immediately riddle the unfortunate little vessel, whose deck is converted into lacework, and whose hull begins to leak, and which will be paralyzed if a projectile touches her vital parts or her engine.

But the musketry that fires from the battery and all along the vessel is not enough. The higher the elevation, the greater the chance of seeing the torpedo boat from afar, and the easier to reach her when she approaches. So the top has become a true fortress. This is reached through the intermedium of the mast, which is of iron and is hollow, and which contains an elevator, as may be seen from the opening at the level of the top in our engraving. Here an officer has under his orders a certain number of fusiliers and gunners charged with the maneuver of the Hotchkiss gun, which hurls thousands of projectiles at the assailant. It is a dangerous post, the guardianship of which is confided to picked men.

As may be seen, we are far removed from those tranquil tops in which the top-men of the old sailing vessels lived in contemplation of the sea, and which they finally loved as their own house; for here, isolated from the rest of the crew, they enjoyed a relative independence.—*L'Illustration.*

THE DEFEAT OF THE ARMADA IN 1588.

THE three-hundredth anniversary of the defeat of the Spanish Armada was celebrated in England in July last with great *eclat*. We give the following illustrations and particulars of the great Armada from a paper by Charles N. Robinson in *The Illustrated London News*.

The conquest of England was considered by Spain as a just and desirable enterprise—and copious testimony exists that long prior to the actual attempt preparations were being made to assail and overwhelm the island and "its brood of vipers."

The Spanish preparations were most complete. The total number of craft of all kinds composing the Armada was, probably, 130; but a few of these never crossed the Bay. At least sixty were galleons of huge size and strength, ranging from 700 up to 1,250 tons burden. They were not, however, primarily built for war purposes, and the proportion of guns they carried was, as compared with their size, not large. But being intended for long voyages, their upper works were high out of the water, and their main timbers 3 ft. or 4 ft. thick. One hundred years before, the Portuguese galleons under Diaz had doubled the Cape of Good Hope, and, with the conquest of Portugal, some of the finest ships in the world passed into the Spanish king's hands. It was the Portuguese galleons that formed the van squadron of the Armada; the largest of them mounting, perhaps, fifty guns, and many of these of small caliber. In the case of the hired ships, except the heaviest Levantine galleons, the proportion of guns to tonnage was still smaller. Usually sailing in smooth water, they did not carry numerous crews, but now they were crammed with soldiers to an inconvenient degree. Of the second class of ships, called galliasses, there were four in the fleet. These were proper war ships, and certainly did their share of the fighting. Like the galleons, they were three-masted vessels, but were also propelled by oars, to pull which they carried a large number of galley slaves. Their prows and sterns were furnished with heavy cannon in high castles, and they carried smaller cannon on the broadside, in ports between the rowers. The two larger each carried nearly 300 soldiers and over 100 sailors, with 350 slaves to row. There were also galleys with one or more tiers of oars a side, many merchant and store ships, caravels, and *urcas*.

The *personnel* of this flotilla consisted of over 30,000 persons, including 18,000 soldiers, 8,000 sailors, 2,000 galley slaves, and a numerous hospital staff, assisted by 180 priests of various orders. The armament was of 2,000 guns; a few may have been 64 or 32 pounders (cannon or demi-cannon), but by far the greater number were 10, 8, or 4 pounders (demi-culverins, sakers, and minions). The whole force was victualed for six months, a large sum of money was taken in the fleet, and the orders for preserving discipline were unusually strict. In the vicinity of Nieuport and Dunkirk, Farnese, the Prince of Parma, had assembled an army of 30,000 foot and 4,000 horse, picked troops, ready to be embarked in scores of flat-bottomed boats and transports, and conveyed across to Margate and Deal so soon as the English and Dutch ships should have been swept from the narrow seas before the imposing array of the "Invincible" Armada.

Of the officers in charge of these vast and apparently overwhelming expeditions, Santa Cruz had seen more service than any naval commander out of England; while Parma was reckoned the first military leader of the time. But Parma never set foot on English soil and Santa Cruz died in February, before the Armada was quite prepared for starting; the Duke of Medina Sidonia, his successor, had little to recommend him for the post save blue blood and personal courage. He had, however, some exceptionally able seamen and commanders as his advisers. Don Juan Martinez de Recalde, Vice-Admiral and Capitan of the Biscayan Armada, was both, and proved it during the whole of the unlucky cruise. He was fortunate, like his chief, in being able to return; but he died shortly after he landed. Don Diego Flores de Valdes, General of the Fleet of Castile, had already served with distinction afloat. He it was who recommended the burning of the English fleet at Plymouth; and he it was, also, who lost heart altogether after the great fight off Gravelines. Don Pedro de Valdes, Admiral of the Andalusian Armada, had commanded a fleet in northern waters, and it was hoped that his local knowledge would prove valuable; but his ship, Nuestra Senora del Rosario (commonly called the Capitana), was the first to be captured and himself taken prisoner. Other commanders of whose exploits we hear are Don Miguel de Oquendo, a dashing and chivalrous officer, in opposition to whose advice the retreat by the North Sea was made; Don Martin de Bertendona, whose flagship, the Ragazona, was always in the thickest of the fighting (he commanded the squadron of hired galleons, among them some of the finest ships in the Armada); and Don Hugo de Moncada, who had charge of the four galliasses, and who lost his life when his ship was taken off Calais. In command of the land forces embarked was Don Alonzo da Leyva, flying his standard in the Rata Coronada, a veteran general who as a youth had crossed sabers with the Moors, and had since seen service in many a land and sea battle. To his charge, we are told were committed most of the high-born youth of Spain who sailed in the expedition. This gallant old soldier, after being thrice wrecked, was eventually drowned, with most of his companions, on the coast of Ireland.

In England a commission had been convened of noblemen and gentlemen, as well as the most experienced naval and military officers, "to sett downe such meanes as are fittest to putt the fforces of the Realme in order to withstand any Invasion." It is worthy of note that, in the opinion of the experts of those days, the only sure means of preventing invasion was in the maintenance of an invincible navy. At the same time precautions were to be taken on shore, in case the enemy should land at Milford, Plymouth, Portland, the Wight, Portsmouth, the Thames, or Harwich. Militia and volunteers in great numbers were embodied, and commenced training in the use of arms; camps were laid out and fortified; while on every high place beacons and bonfires were prepared for lighting to give information of the advent of the foe and summon the defenders of the state. These preparations were confined to no single part of the country or to any particular class or creed. Many places, like the City of London, came forward to do their duty by assisting, not only with land but with sea forces—raising loans, finding ships and men, victualing and arming them. Everywhere there was but one desire apparent; and Protestants and Catholics, the classes and the masses, vied with each other in displaying one mind—to take up arms and, if need be, to lay down their lives in the defense of their rights and privileges against the threatened tyranny of Spanish rule.

To give them their due, there were many among the gallant seamen and soldiers of the time who neither feared nor underestimated the Spanish power. While the patriotic spirit which was aroused is well exemplified by the conduct of the pirate who is said to have walked into the hands of justice that he might give timely notice of the coming of the hostile fleet, at the same time the remark which Sir Francis Drake is reported to have made when interrupted in his game of bowls on Plymouth Hoe, "There's time to win the game and thrash the Spaniards too," is an instance of the contemptuous feeling in which the invaders were held by those best acquainted with them. The bold merchant adventurers, buccaneers, or smugglers—call them what you will—who had fought and thrashed the Don afloat and ashore — not without getting hard knocks in return—saw in the huge armament then entering English waters, if not fresh opportunities for plunder and prize money, at least a great chance to pay off old scores. They reckoned the slow, ponderous, badly armed, and overcrowded galleons at their real value, and never doubted for an instant the outcome of the maritime fray, so long as they could get a sufficient supply of stores and ammunition from the authorities.

The total number of ships in the Navie Royal was thirty, big and little, the four largest being the Triumph, Elizabeth, White Bear, and Victory, all built from the designs of Sir John Hawkins, Treasurer of the Navy — seaman, shipbuilder, and navigator — a man, indeed, to whose fertility of resource and skill, as much as to the capacity of any other man of the time, must be attributed the victory which followed. Then, as for long afterward, there was no peace south of the Line, and every merchantman was forced to go about its business armed, while it was customary to call upon the seaports for their ships in war time. So the numbers of the fleet were soon increased. Altogether, the English fleet consisted of 197 vessels, many of which were mere pinnaces and coasting craft. The force embarked was about 15,000 men; but the proportion of seamen to soldiers in each ship was much greater than in the invading force. Holland also sent a contingent of ships, under Justin of Nassau. These Dutch ships do not appear to have met with the vessels of the Armada, but they effectually did their work on the Netherland coast.

The English flag ship was the Ark Royal, a vessel of 800 tons burden, carrying 425 men and an armament of which the following summary is probably correct: 4 cannon (60 pounders), 4 demi-cannon (32 pounders), 12 culverins (18 pounders), 6 sakers (6 pounders), and some smaller ordnance. These last named were styled port pieces and fowler halls, small guns made in two parts, the chambers being ready charged, and placed in the piece when needed. The largest guns were usually mounted as chase pieces, in the stern; demi-cannon and culverins in the broadside ports, which were frequently circular in shape. Sakers, minions (4 pounders), or falcons (2 pounders) were mounted on the quarter and forecastles, on blocks of wood or as swivelpieces; while the smallest ordnance, sometimes called "murdering pieces," were placed on barricades inboard for use against boarders. From the tops also were used "fyrevorkes," of which the Spaniards were reported to stand in great dread.

The ships were gayly ornamented with carvings on their woodwork, their sternposts and figureheads being often works of art, beautifully carved, moulded, painted and gilded. Then, too, there were the great poop lanterns, and from every conceivable point aloft hung the banners and "ancients" of the leaders and the national emblems. The length of these banners and pennons may be judged by that one which, in memory of this very event, was "set up in the great church of Leyden, in Holland, and being fastened to the very roof, it reached down to the ground." Some curious information about the cost of these flags is extant—as for example, we read that Henry Holesworth, of London, May 21, 1588, supplied fourteen flags of St. George of "fine beaupres" for the use of her Majesty's ships and pinnaces at Chatham, one at £4, eleven at £3, and two at 20s. the flag.

John Heath, of London, also supplied two ensigns of silk, one for H. M. S. Rainbow, at £5 6s. 8d., and another for the galley Bonavolia at £8 6s. 8d. William Byford, of London, also provided forty-six streamers or pennants for the use of the Ark Royal, the Victory, the Mary Rose, and the Swallow, at 20 pence apiece. Again, Lewis Lidyard, of London, had 102 yards of calico, used for making two flags, stained in colors with her Majesty's arms, "to be worn at sea in the ship the Lord Admiral sailed in," at 9d. every yard, £3 16s. 6d.; and moreover for staining the said flags and bringing them from London to Queenborough, by Chatham, £6 16s. 8d.; total, £11 2s. 2d. The manning of the ships, whether of the navy or of hired or volunteer merchantmen, was most imperfect; pay was generally in arrears; and sanitary arrangements being totally wanting, disease and sickness were rife.

The most illustrious and notable of the English sea officers was Lord Charles Howard of Effingham, Lord Admiral, as his father had been before him, a man of considerable experience at sea at the time of the threatened invasion. To his caution, coolness, judgment, and, in particular, his ability as a naval tactician, the victory in 1588 was in no small degree due. To understand the difficulties with which he had to contend, his correspondence must be read. The constant burden of it is, that while he had the ships and the men—the latter as good as any in the world, and ready to spend their lives in her Majesty's service—money, stores, ammunition, and provisions were all lacking. And so it went on to the end of the campaign. So far as concerned a constant attention to the details of his office, a zealous care for his men, and a courteous consideration for the advice of his counselors (some of whom were more noted for temper than tact), the Admiral did wisely; and when the moment arrived to try conclusions with the enemy, he proved himself amply endowed with true courage and valor. The four men whom Lord Howard chose as his advisers, and of whom he writes, "The worlde dothe judge to be men of the greatest experience that the realme hathe," were Sir Francis Drake, Captains John Hawkins, Martin Frobisher, and Thomas Fenner. Of these four, Sir Francis Drake has by some writers been made the central figure of the defeat of the Armada. His chief exploit was the taking of Our Lady of the Rosary, the Capitana of Pedro de Valdes. Drake's conduct on the Hoe at Plymouth, if the story is true, was hardly that of a zealous subordinate, wishful to give a good example to the men under him. Disobedience is generally charged to him also in the matter of carrying a light on the night of the fight off the Start. His conduct in the action off Gravelines was that of an impetuous, brave, and daring officer, and he was indisputably a capital seaman and an intrepid commander; but he appears, possibly from old associations, to have allowed his lust for dollars to detract from the duty he owed to his chief and his country. Captain John Hawkins came of a seafaring family. He was a Devonshire man, while Drake, also, was a native of Tavistock, and Frobisher hailed from the county of York; but all sections of the country may fairly claim to be represented among the sea commanders on this eventful occasion. Hawkins' father was a famous shipbuilder of Plymouth, and well known as an expert navigator in the time of Henry VIII. Hawkins' son, too, Richard, who commanded the Swallow against the Armada, was noted as an able seaman; and, in his "Observations," has given us a most valuable record of the manners and customs of the Elizabethan sailors. Under Captain John Hawkins, Drake was trained; and many of the best sailors and navigators of the time had been in the forecastle or officers with him.

Among the first and foremost of the distinguished seamen of his day was Martin Frobisher. His indomitable bravery and buildog courage in the fight off Portland was rightly recognized by the honor of knighthood conferred on the following day. Frobisher's true claims to the gratitude of all Englishmen have lately received attention at the hands of the Rev. Frank Jones, whose valuable and interesting account of the life of this gallant seaman and discoverer deserves to be widely known and read. Of the brothers Fenner, Thomas, Edward, and William, who respectively commanded the Nonpareil, Swiftsure, and Aid, little has been written and but little appears to be known. All these brothers did good and gallant work; and Thomas appears, from a letter of his which still exists, to have chased the flying Spaniards farther north than most of his brother commanders.

Lord Henry Seymour carried out his work with praiseworthy assiduity: particularly gallantly did he fight on the day of the battle off Gravelines. Sir W. Wynter, his Vice Admiral, an old and able officer, did excellent work the same day. He was master of the ordnance, and, nearly thirty years before, had seen service in command of a squadron against the French in the Firth of Forth. He came of an old and distinguished Gloucestershire family; and Captain Wintour, of Ryde—the proper spelling of the family name—is associated with Major Martin Frobisher, Mr. Stuart Hawkins, and Dr. H. H. Drake, among the committee for the tercentenary celebration.

It is very generally believed that, in every respect, the Spaniards were superior; but this is now known to be an erroneous idea altogether. In numbers, owing to the division of the English squadrons, the Armada was superior; and, coming down to the distinctly fighting ships, the totals, as given by Professor Laughton, were of Spaniards, 62; of English, 49. But in maneuvering power, and in weight of metal, the advantage is shown to have been quite the other way. Charnock lays great stress on the superior handiness and speed of the English ships, and Laughton, who has probably given more study to the subject than any one else, appears to have conclusively proved that in the mat-

ter of armament the Spaniards were also overmatched. Nor were these the only advantages possessed by the English, which, while they do not detract from the remarkable prowess and skill of the English commanders, bear out the naval historian's contention that no miracle or special intervention of Providence was required to insure victory to the English arms. Our seamen were the most skillful and dexterous in the world. They were rough-weather men, used to hardships, and living a great part of their time with their lives in their hands. They knew their officers, and were known to them. Each was proud of the other, and a comradeship existed between the quarter-deck and the forecastle, entirely unknown in the Spanish service. Then they not only knew their officers, but they knew their ships, and how to handle them in all weathers and

"A TALL SPANIARD."

under most circumstances. As Sir Walter Raleigh and Sir William Monson tells us, they had introduced many improvements in rig which the Spaniards, who were principally "trade wind" sailors, had no knowledge of. The science of gunnery at this time was almost unknown, and archery formed a branch of it; but the Englishmen had made it a study, while the Spaniards despised it, regarding the sword as the more noble weapon. To this feeling and to the number of soldiers carried in the huge castles of their galleons may be ascribed their constant attempts to board. Altogether, we shall not be going beyond the mark in saying that, so far as the seaman's skill and the gunner's art are concerned, the Spaniards were utterly and entirely beneath comparison. At the same time, it must not be forgotten that during the first week's fighting, the numerical superiority of the Spanish to their assailants was something like six to one.

May 29–30, 1588, "La Felicissima Armada" sailed from the Tagus. With great pomp and circumstance the mighty fleet left, in charge of the Duke of Medina Sidonia, and could it then and there have proceeded direct to these shores, history might have had a different tale to relate. But, in those days, sailors had to reckon with the wind and the weather, and these proved so tempestuous that the squadrons of galleons and storeships soon separated, and it became impossible to proceed. Some were dismasted, one or two totally lost in the Bay, and though a few of the ships are said to have gone on and sighted the Scillies, all of them had eventually to put back and seek shelter in the Groyne. The damage done, the time lost in getting the ships together again and revictualing them, with other matters, were made reasons by a council of war at Corunna for urging a postponement of the expedition. Philip, however, was inexorable, and ordered immediate departure. And now a story reached Sidonia to the effect that Howard had laid up his ships for the season; it was, therefore, determined to stand boldly for Plymouth, and, if possible, surprise and burn the English fleet, and perhaps effect a landing.

July 12–22, a Friday, the Armada sailed with a fair breeze from Corunna. After a nasty passage, baffled by contrary winds and calms, and scarcely propitious of success, on Friday, July 19–29, they entered the Channel and sighted the Lizard, which they took to be Rame Head; so they stood off for the night. They had, however, been seen by Flemming and other scouts of Howard's.

Ten successive days of hard fighting followed, during which, at almost every encounter, the English inflicted demoralizing blows. Then the Duke of Sidonia called upon his officers for advice as to what should be done, and all the members of the council agreed that "the Armada ought to put back into the channel if the weather allowed of its doing so, but if not, that, yielding to the weather, they should return by the North Sea to Spain." With this sop to their consciences they stood away to the northward, and the English left them to the care of the elements.

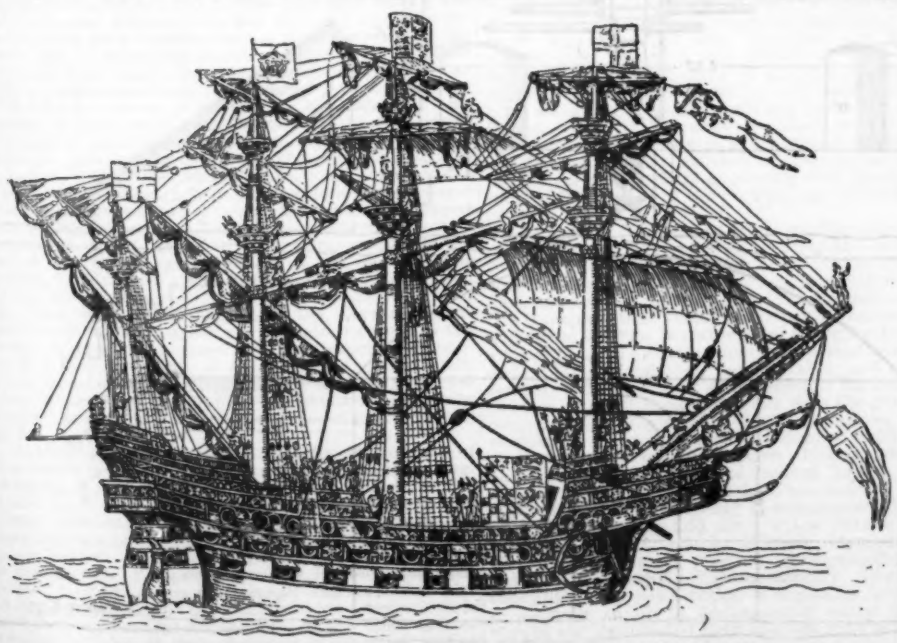
The "invincible" Armada came, saw, and fled, the remainder of the story of the ill-fated expedition being merely a record of the difficulties, dangers, and disasters which befell the remnant in attempting to clear the Scotch and Irish coasts on their journey home to Spain. Thomas Fenner, who followed them as far as the Firth of Forth, and left them on August 4, with a couple of pinnaces to keep an eye on their future move-

OLD ANCHOR IN WHITEHALL YARD, BELONGING TO A SHIP OF THE SPANISH ARMADA.

ments, records their utter demoralization. The gale increased, none stopped to succor a comrade, many foundered in the North Sea or were wrecked on the Scotch coast, more came to grief on the rocks of Ireland, and of the vessels which left the Tagus, barely half returned. Of the 30,000 men who sailed in the Armada, scarce one-third got back home again; those that the bullets of the English did not reach fell victims to the winds and the waves, the rocks and the shoals, hunger and thirst, or the savages of Ireland.

This was a sufficiently tragical termination to the expedition which less than a twelvemonth before had menaced the country so terribly. Never since has the English nation been exposed to a danger seemingly so imminent and so overwhelming. The lessons of the occurrences sank deep into the hearts of the people of that time. Their importance is not lessened by the three centuries that have passed. The defeat of the Armada taught friend and foe alike that Britain's shores are inviolate so long as Britain's fleet is efficient. The peril was undoubtedly increased by the procrastinating imprudence and vacillating policy of the authorities. It is a sufficient commentary on the state of affairs on shore that the preparations for the protection of the Thames were not even completed at the date of the fight off Gravelines. At the time that Queen Elizabeth was reviewing her troops at Tilbury, the Armada was a scattered and defeated host. It was no mere chance, too, as Professor Laughton points out, that made our ships more handy, more weatherly, and more heavily armed than those of the enemy. These advantages were due to the foresight and enterprise of the English naval commanders, and not to them was the shame that these memorable battles were fought and the discomfiture of the enemy assured by seamen whose wages were unpaid, who were half starved, and lamentably ill-supplied with the munitions of war.

The old anchor represented in one of our smaller engravings lies, with several other naval trophies, outside the building of the Royal United Service Institution, in Whitehall Yard. It was found on the coast of Donegal, where, and on the coasts of the Bay of Sligo, of Mayo, Galway, Clare, and Kerry, many of the ships of the Spanish Armada were wrecked on their way homeward from the North Atlantic. This anchor was presented by Admiral Ommaney, R.N., to the United Service Institution.



THE ARK ROYAL, THE FLAGSHIP OF THE ENGLISH FLEET.
[From a Print in the British Museum.]

[THE ENGINEER.]

FRENCH DISAPPEARING TURRETS.

THE Compagnie des Forges de Chatillon et Commentry, Paris, has long worked at the development of war *materiel* in steel and iron, and has supplied armor for over twenty-seven ships of the French navy, and it has lately made shields of special construction of compound steel. It is found that a greater resistance may thus be secured than with solid steel, because the desired hardness of surface may be obtained without the liability to through fracture which generally besets steel, and sometimes, as experience has shown, spontaneous fracture occurs with steel of harder kinds.

Special stress is laid on the application of the lead baths for hardening or tempering, to which we referred in *The Engineer* of June 1. In the case of armor plates, the equalization of heat, owing to the conducting power of the molten lead, is specially valuable. This, with its use for gun tubes and projectiles, we noticed in the article referred to. The application of it to the case of armor made up of layers of different kinds of steel is, however, a new feature. We have repeatedly spoken of the theoretical advantages offered by the compound principle applied to steel—on the first occasion, we think, in 1883; but we have never heard of makers being quite satisfied with the result in this country.

The Company Chatillon and Commentry is at present employed by the French government in making disappearing turrets, of which trials are to be made at Chalons. The extent of vertical movement given to the turret in its extreme positions is 80 cm. (3·14 ft.) It takes seven seconds to raise the turret into the firing position, and five to lower it. The turret rises, discharges its guns, and disappears in fourteen seconds in all. The ports are covered four seconds after discharge. Since the Bucharest competition, early in 1886, the company has pushed forward new designs, profiting by the experience hitherto obtained; and disappearing turrets are considered to have special recommendations—now that the power of artillery fire has so much increased. This turret—the invention of Colonel Bussiere—differs from those given in *The Engineer* of February 11, 1887, page 109, chiefly in the fact that the roof is dome shaped. This has been found desirable to resist vertical fire, a flat roof having on one occasion yielded to the attack of very heavy mortars.

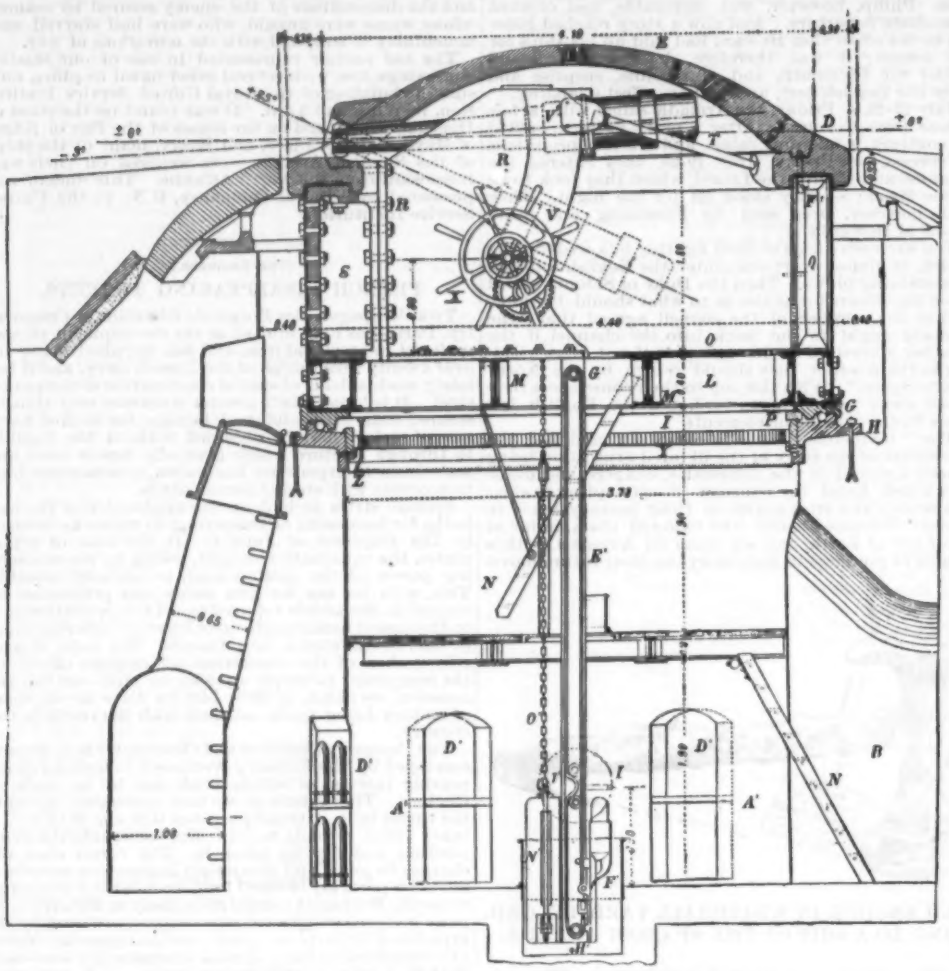
It is not necessary to give a figure of the disappearing turret, which is nearly identical with that before referred to in *The Engineer* of February 11, 1887, page 109, chiefly in the fact that the roof is dome shaped. All the designs have some features in common. All have dome-shaped roofs, and all have the old glacis plate prolonged into a conical wall to prevent the earth and masonry being driven in beneath the old glacis plate, thus choking the space between turret wall and surrounding mass of earth or concrete.

Cupola for Two Guns of 15 cm. (5·91 in.), 25 Calibers Long, Cie. des Forges de Chatillon et Commentry.—The above company has endeavored to realize the complete isolation of the cupola, as the experiments made in different countries of the fire of explosive shells has shown that the violence of the current of air occasioned by the explosion may expose the interior to serious danger. The cylindrical part is enveloped for this purpose in a simple vertical plate, embracing the structure and completely isolating it from the circular passage running round it in the interior of the fixed well.

The circular revolving crown, if it is furnished with conical trucks, is itself protected with a species of petticoat ("jupon") in plate iron, covering the empty space between the trucks. If, on the contrary, the revolving trucks are spherical, they run in a double circular groove existing both in the fixed and in the movable part, and the four lips thus obtained form two successive joints almost approaching contact, with only 2 mm. or 3 mm.—0·08 in. or 0·12 in.—of play. The obturation can be completed by shutting the exterior joint by a circle of hemp. The apertures for aim and ventilation in the spherical dome are kept habitually closed by plugs, and the embrasures of the guns are reduced to a minimum by the spherical construction of the carriages.

As the complement of these arrangements, the interior disposition and working is studied in such a way as to free completely the center of the cupola by bringing all the organization of the service of the guns into it, without having to pass by the circular corridor, as has been hitherto done. We must admit, in fact, that this corridor would become absolutely untenable under the action of the explosive shells actually employed. It only communicates with the lower galleries by a passage kept closed by a metallic flap. For the shield the spherical cup form has been adopted, the advantages of which were clearly shown by the experiments at Bucharest.

The inclination of this shield to the horizon is, at its foot, only 34 deg. The dome does not form by itself the edge of the ring-shaped space which separates it from the front shield. This arrangement, hitherto maintained, has the grave inconvenience of leaving the edges of the cup without support, in spite of the fact that they form the most exposed region, and might consequently be fractured under the shock of projectiles. It further necessitates an excessive widening of the empty space round the cupola, on account of the inevitable irregular movement of the dome, which it is necessary to guard against, and it finally places this space in a re-entering angle, which favors the accumulation of the *debris* of projectiles and of materials, and the entrance of gas resulting in explosions. To avoid these dangers, the shield rests on a strong metallic ring forming a bed above the structure of the body of the cupola, and constituting the movable edge of the ring-shaped space. This ring bed, which embraces the entire circumference,

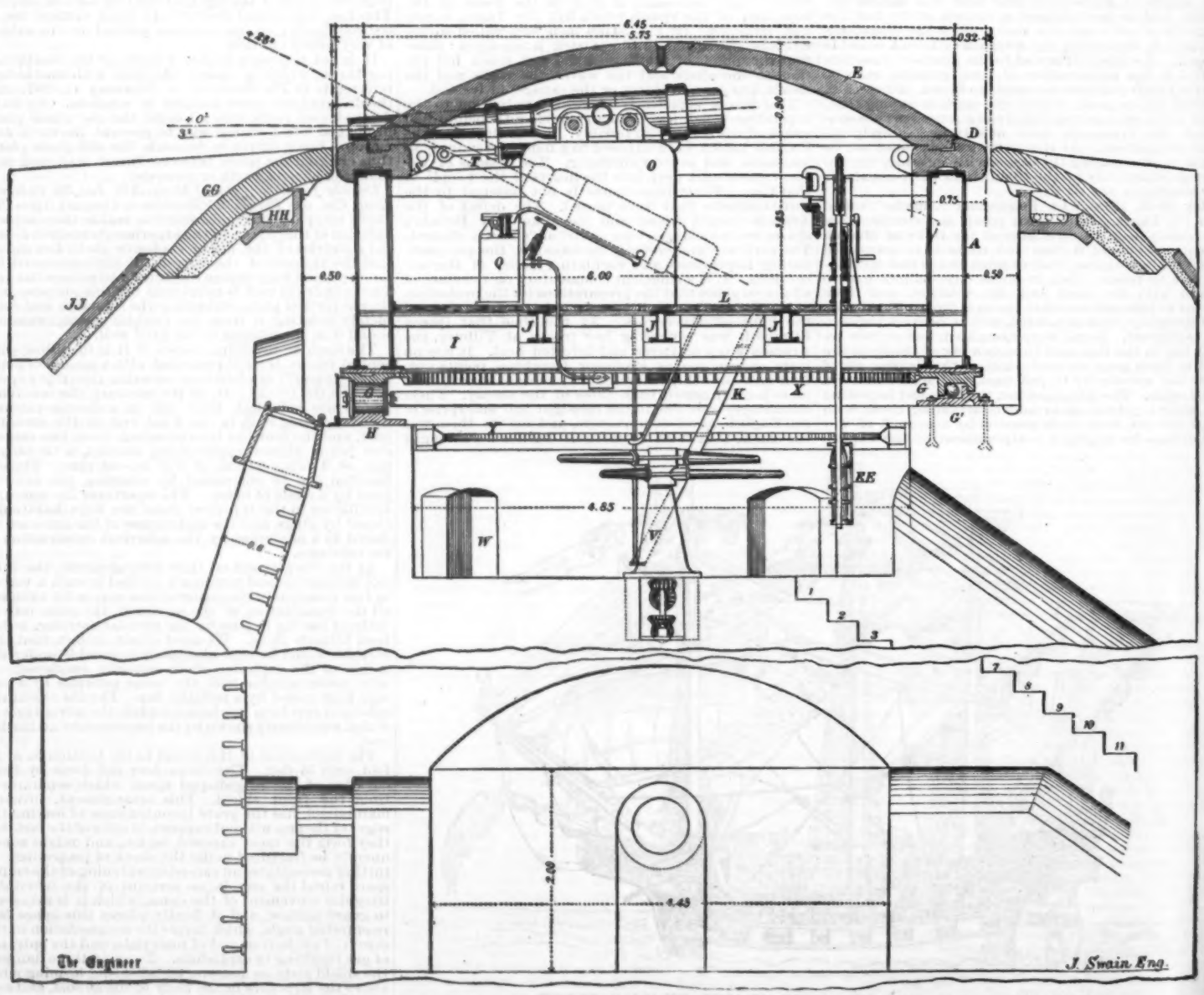


DISAPPEARING SINGLE GUN TURRET.

has its upper surface continued in the prolongation of the glacis; as its breadth is important, it decreases by so much the ring-shaped space at the foot of the shield, and thus closes the foot of the re-entering angle, where it presents the most danger. This ring further offers the advantage of bringing to the shield a consolidation almost indispensable when it is in many pieces; it resists the wedging pressure of the segments of the roof under the shock of projectiles; it supports the edges, whose cracking it hinders, and it assures the duration of the cupola by resisting the distortions of the shield. It thus permits the circular space to be reduced to its minimum width, and consequently to intercept more efficaciously the passage of the fragments of projectiles and even the expansion of gas. The metal of the cupola is of chilled steel tempered in a metallic bath of a conductibility superior to that of liquids. This mode of tempering, which gives to the steel the properties of the best wrought iron, simplifies the manufacture of shields while assuring to them a great ballistic resistance. It allows of the manufacture of pieces of every shape, whose weight and dimensions are only limited by the means of transport, and it reduces the number of pieces, which always form weak joints. The cupola body is also entirely isolated from the passage in order to preserve it from gaseous currents produced by the explosion of shells. The exterior wall consists of a plain sheet of iron with the revolving conical trucks, G, which leave free an important space. The closing of the cupola at the bottom is obtained by means of a sort of petticoat ("jupon") of sheet iron formed of independent segments which are applied to the crowns by the very pressure of the gas. In an alternative arrangement of the balls shown at G, tight closing is insured by means of a simple rope interposed between the two lips of the crowns. The fact that the embrasure is brought to a minimum completes the isolation of the cupola.

The service of artillery pieces takes place entirely in the interior. The centering and rotation are sufficiently assured by the revolving crowns. An arrangement of rotation has been adopted, applied to the toothed wheel at opposite points of the circle, to insure symmetrical action. The duration of one rotation may be estimated at two minutes without great effort.

Detailed Description of the Cupola.—The movable body consists of four plates of iron, A, of 30 mm. (1·18 in.) of thickness, the joints being covered by protecting pieces. This plate iron forms a circle, whose exterior diameter is 6 meters (19 ft. 8·3 in.) The height of the cylinder thus formed is about 2 meters (6 ft. 6·7 in.); thirty ribs of double T iron riveted in the interior of the frame form as many solid lines. They receive in the upper part a thick sheet of iron, fixed by angle iron, from which the ring D takes its support. This ring has in its upper part a groove into which fits the base of the dome, E, which is cast in two pieces, of which one bears the tongue and the other corresponding groove.



FRENCH DISAPPEARING GUN TURRET FOR TWO GUNS.

A certain number of bars crossing the ring are screwed into the lower part of the dome, which they thus unite to the ring and to the body of the plate iron. At the lower part of the latter are riveted plates and angle iron forming the supporting bed of the upper circle of rotation, G. A lower circle of rotation, H, corresponding to the one above it, is fixed and bedded into concrete.

Between these two rings are placed either conical trucks or balls to reduce the work of rotation to a minimum, which may be effected by men working on the levers of the capstan, V. Three iron ribs at I, with T iron held to the moving structure, support the cheeks of the carriages. Three transverse ribs, J, form, with the first three, the structure of the platform. A floor covers this structure. Two ladders, K, fixed underneath the floor furnish means of communication between the intermediate chamber containing the capstan and that containing the guns. Two movable panels, L, furnish a passage for mounting and dismounting the guns. A brake worked from the interior fixes the position of the cupola during firing. It consists in gear acting on a screw which acts through the medium of a sabot on the rotation circle.

Each carriage is composed of two iron cheeks, O, riveted to the ribs of the floor. These cheeks are strengthened transversely by strong transoms of cast iron or hard steel. Between the cheeks is a cross piece resting on the head of a hydraulic piston which serves to give elevation. The piston is worked by a pump, Q, of gun metal. The gun is held by its trunnions in two grooves, furnishing longitudinal movement in its carriage.

The system rotates on the pivot, S, under the action of the hydraulic press, by means of the bar, T, on which it slides. The recoil is limited by means of a hydraulic brake, of which the cylinders, U, are fixed under the gun. On the intermediate stage and on the center vertical shaft is placed a double capstan, V, acting by means of conical and cylindrical pinions on a toothed arc, X, strongly bolted to the lower part of the moving system. Immediately beneath the racers is the circular graduated scale, Y, for horizontal direction. A needle serves as an indicator. The projectiles are brought into the lower chamber by a gallery. A lift let into the wall and worked from this chamber raises the projectiles into the intermediate chamber, and they are placed either in the niches or in the second lift, E E, which carries them into the body of the turret; this lift, fixed to the ribs of the floor, is worked from the interior of the gun chamber. In order to save time, two lifts are so arranged as to raise a shell during the descent of the empty lift, which ought to take the next shell. The "avant cuirasse," or glacis plate, is made in three pieces: (1) A crown, G G, of cast steel or chilled iron strengthened at the upper edge, and made in eight similar segments; (2) a supporting ring, H H, of cast steel in eight pieces, resting under the upper edge of the crown and bedded in cement; (3) an exterior ("jupon") crinoline or petticoat of thin steel of segments united by strong angle pieces of steel. This forms the continuation or prolongation of the cone of the glacis plate.

Cupola for One Gun of 12 *cm.* (4·72 *in.*), *with Non-recoil Carriage.*—The cylindrical body of the cupola has an exterior diameter of 4·4 m. (14 ft. 5·3 in.), and is composed of nine bars of iron and transoms. The ring, D, is cast in two pieces. It acts as a support to the roof, E. The one and the other are of steel, lead-tempered and annealed. The roof is cast in one single piece; it rests on the walls at F. G and H are two circular racers for turning—the one above and the other beneath. The latter is firmly fixed to the concrete by bolts.

Between the two racers are either metal balls or conical trucks. The rotary movement is supplied by a toothed arc, I, pinned to the racer, H, and engaging with the pinion which is at the extremity of a vertical shaft, to which the movement is communicated by a wheel with axle working upon a double band. Two solid bars, L, of hardened steel, united to th cylindrical body by their extremities, support the cheeks of the carriage. Two small bars, M, constitute, with the two bars, L, the structure of the platform. A movable panel, O, of the platform furnishes a passage for mounting and dismounting the gun. The check, P, worked in the interior of the chamber containing the gun, determines the position of the turret during action. It is composed of a separate wheel, Q, working a screw, which rests by a sabot on the toothed wheel. The carriage is composed of two cheeks, R, whose lower parts are firmly fastened to the principal bars of the platform, and which are united vertically to the cylindrical body by a massive piece of chilled steel, S, in the form of a U, replacing at this point the rib work of iron and transoms of the cylindrical structure. At the upper part these cheeks are united to the ring, D, on one side by strong bolts, and on the other by two cranks or strong legs. The muzzle of the gun passes through a spherical collar piece adjusted to the embrasure. Behind the trunnions the gun is fitted into a jacket, V V^1, whose two pivots run in the grooves of the cheeks. These grooves have as their axis or center the center of the spherical piece, through which passes the chase of the gun. The recoil of the gun is thus prevented, and its shock is mainly transmitted to the upper mass of the movable body of the cupola. The jacket, V, is united at its lower portion by a toothed sector worked by means of gear by the spoked wheel, X. This mechanism constitutes the elevating gear. In order to reduce to as little as possible the work at the wheel, the gun is balanced by a counterpoise, N^1, fastened to the extremity of the chain, O^1. This chain turns upon a drum of spiral form in such a manner that the arm of the lever of the counterpoise varies proportionately to that of the center of gravity of the gun.

At the lower part of H, the racer for the rotation of the turret, is fixed the graduated arc, Y, for pointing. A needle, Z, placed under the platform, determines the angle for this. The projectiles are brought to the lower chamber, A^1, by the gallery, B^1. The niches, D^1, built into the masonry, are intended for a limited store of projectiles. The raising of the charge is effected by a vertical tube, E^1, open on one of its sides, and fixed at its upper end to the platform of the movable body. A lift, F^1, receives the projectile and the charge. It is attached to a support which turns in the open end of the hollow tube. A chain fastened at the upper end of the support raises and lowers the scuttle in passing over the blocks, G^1 and H^1. In the action of the winch, I, lowered upon the shaft of the axle, J^1, which works the endless chain, the scuttle takes a movement and conducts the projectile and the charge in the chamber of the cannon. Communication is effected between one platform and the other by the steps, N. The glacis plate is composed like that of the cupola for two cannons, being of the prolonged form already mentioned.

THE PRALL SYSTEM OF DISTRIBUTING HEAT AND POWER FROM CENTRAL STATIONS.*

By E. D. MEIER, Member of Engineers' Club of St. Louis.

HEAT is the condition of all life and the foundation of all power. These facts, so clear to the modern engineer, were foreshadowed by the imaginative Greek who invented the myth of Prometheus, that demigod who snatched from Olympus the living fire which was to enable mortal man to become even as the gods themselves. They were the living truths underlying the fire or sun worship of the Parsee race. In this sense the mechanical engineer may lay claim to a spiritual ancestry far antedating that of the proudest monarchs of the world.

We now know, what they darkly felt or imagined, that the sun is, for us at least, the source of all power and the upholder of all life. Not only does he lift up millions upon millions of foot pounds of energy in the vapors which he raises from the sea to feed the water powers of the highlands of our continents, not only does he direct and limit the forces of the winds which still continue to do so much of the world's work; but we know that ages ago with beneficent profusion he stored up for us in the coal measures a limitless supply of force, which we can at will liberate from its long imprisonment and turn to our uses. To-day this antediluvian supply determines by its location and condition where the great hives of modern industry shall be planted. But we must modestly confess that we have not yet learned the A B C of economy in the use of this great gift of nature.

If we will put aside those facts and statements based on the best foreign or the best Eastern coals, and confine ourselves to what lies nearest at hand, which is of course the problem for us to solve, we find that:

The best possibilities in our average Illinois coal are the liberation of 11,580 heat units from each pound of this fuel consumed. We have theoretically necessary to give us one horse power per hour 2,565 heat units. Hence one pound of coal burned per hour should give us 4½ horse power. But we find that our best steam plants, with high pressure engines of the Corliss or an equally economical type, coupled with the best boilers, require three pounds of coal for each horse power per hour, which is equal to 13½ times as much fuel as it should take theoretically. And this may be placed as for our locality the best present possibility in practice, which can only be reached in large plants, where both the engineer in charge and the firemen at boilers are considered, taught, and paid as skilled laborers. In most smaller plants, where a cheap boiler and cheap engine, pipes poorly covered (or perhaps not covered at all), are handled by underpaid and consequently unskillful or careless men, from eight to eleven pounds of coal are used per horse power per hour, which is from 36 to 50 times as much as theoretically necessary, and from 2¾ to 3¾ times as much coal as would be used in plants attaining the practical minimum above stated. But I know of cases where the record shows a consumption of 80 times the theoretical quantity, or six times the quantity of fuel for each hour's run that is actually used in the best class of plants before described. Now since the best types of engines and the best types of boilers, the best types of heaters and all other appliances, cost very much more per unit of power for small plants than for large ones, and since the higher grade of intelligence, in what is one of the highest and most useful branches of manual skill, can only be had for proportionately good pay, it is clear that we cannot expect to develop anything like the economy aforesaid in small plants scattered all over the city, under sidewalks or up in garrets, etc. Furthermore, the principal danger about the steam plants will always be located in the boiler room. And you cannot but regard it as a great mistake that the good old rule which insisted on placing the boilers entirely outside of factory buildings is utterly disregarded in the smaller and larger plants scattered about populous cities for such purposes as heating, cooking, running elevators, printing presses, sewing machines, electric light plants, etc. A recent report of a board of experts consisting of Profs. R. W. Raymond and Geo. Plimpton and Mr. C. C. Martin, C.E., refers to this matter as "the growing danger from steam boilers of all sizes distributed in buildings and under sidewalks, and employed in running elevators, dynamos, printing presses, and other machinery. That destructive accidents from this source have hitherto been few is a gratifying circumstance, which must not be permitted to obscure the fact that the danger is constantly increasing with the number of such boilers and with the growing age of those now in use."

Add to this the danger from conflagrations in the overheating of flues entirely inadequate to the work they are called upon to perform; the cost of bringing in coal and carrying out ashes to and from places narrow, dark and scarcely accessible, and the dirt accompanying this transportation. Consider further the smoke and soot and worse still the invisible gases of combustion which vitiate the air in rooms in which numbers of men, women and children spend their days in labor, and even perceptibly affect the very atmosphere of the streets, and the fact that all these evils grow with the greater concentration of the best part of our population, *i. e.*, the workers, in districts where the height of buildings constantly increases with unchanged width of streets. We have then reasons enough to account for the many attempts which have been made to concentrate the work of producing this heat energy in certain central stations, near the fuel supply and more or less remote from the localities where it is to be utilized. Pittsburg's phenomenal and almost magical transformation by its natural gas supply has necessarily directed our thoughts to the substitution of a gaseous fuel, flowing in constant supply in underground mains under the streets, and distributed right and left alike to manufactories, office buildings, and private residences. There are hundreds of gas producers either seeking for recognition or actively at work on this problem. At the outset it behooves the engineer to inquire into the possible or probable limitations of such a system. The example of the gas light companies teaches us that even with low pressure in the mains, leaks are constant and unavoidable. Increase enormously the quantity of gas required, and we must either use very much larger or a greater number of pipes, or resort to pipes as strong and joints as carefully and securely made as those which gave the Philadelphia Co. in Pittsburg its great success. Pittsburg has not yet eliminated natural gas explosions from its weekly history, although they may no longer create a sensation. But the necessity of the expensive, because thorough, methods of the company aforesaid is acknowledged, and to such methods alone can we look for the prevention of gas explosions. Whether the minor leakage along such lines, causing impregnation of the soil, corrosion of the lead water pipes or of the electric insulators, and possible vitiation to the atmosphere sufficient to intensify if not to create epidemics, may not in course of time show even natural gas to be a not unmixed blessing, we cannot here discuss. The precautions, dimensions, and mechanical contrivances found necessary in Pittsburg's excellent system will no doubt limit the supplying of manufactured fuel gas to certain districts where the quantities are great and the necessities imperative. Furthermore, the fuel gas solves but the first half of the problem in furnishing the fuel in the exact condition in which it can best be burned, while the great multitude of small consumers, who will always create the bulk of the demand, require not this small material, but the manufactured product, *i. e.*, the heat energy itself ready at hand in the smallest subdivision. I am, therefore, convinced that fuel gas when its use becomes general will be distributed direct to certain larger plants, where the best appliances and the most skillful handling can be had, and that from such the live heat energy will be portioned out to the army of small consumers.

Large central steam plants have been and are being successfully operated in favorable localities, and where they have been originally designed and built with great scientific knowledge and practical skill. Where these have been wanting they have failed, always will fail, and ought to fail. They naturally require very large pipes and joints difficult to make and more difficult to keep tight, because not constantly accessible. Steam being very elastic cannot be pumped or forced by mechanical means, but finds its own velocity at the expense of loss of pressure, loss of temperature, and continuous condensation. From these result the always annoying and sometimes dangerous "water hammers" and wet steam and other kindred evils for the consumer. And these evils increase proportionately the larger the demand for heat or power made upon the pipes, so that invariably when most needed the service is least good.

Hot water, i. e., very hot water, a great deal hotter than any one has ever *seen* it, next offers its solution. Water, having the greatest capacity for heat of any known substance (except certain chemical solutions valueless for practical purposes), has been chosen as the measure of specific heat for all substances. A cubic foot of water at 400° F. carries 22,000 heat units, while a cubic foot of steam at the same temperature carries but 682 heat units, *i. e.*, but 1/32 as much. There is no difficulty in forcing water, under any pressure, through pipes at a speed of ten feet per second. Steam can be made to travel much faster, but many practical considerations limit the safe speed in long pipes to about 60 ft. per second. While no hydraulic engineer would hesitate at pressures in water from 400 to even 1,000 pounds per square inch, I doubt if any steam engineer would have the hardihood to propose supplying a large and complicated network of underground pipes with steam at much more than 100 pounds pressure. If we assume 125 pounds gauge pressure (equal to 140 pounds absolute) as the present practical limit, we find that our cubic foot of steam carries 376 heat units, or about 1/59 of the quantity held by one cubic foot of water at 400° F. From practical considerations such as these we may then deduce the statement that a steam plant should have five to ten times the pipe area of a hot water plant, *i. e.*, its pipes must have from 2¼ to 3¼ times the diameter of those of the hot water system.

While there have been earlier systems of hot water supply, limited in extent, and some are to this day running with eminent success, the Prall system for supplying heat and power from central stations is, I believe, the first which has been put successfully into service on a large or metropolitan scale. A short description of the system will show where it differs from its precursors in methods and appliances.

We have first a central station with its batteries of boilers of a safety pattern, *i. e.*, constructed with comparatively small shells and small tubes, all with internal pressure, so that all parts of the elastic steel structure shall be in tension, and with a circulation so positive that differences of expansion, which would be caused by differences of temperature, are eliminated. Next, in addition to the ordinary feed pump, we have a pump or a number of pumps for taking the water from the boilers and driving it through a series of street mains carefully wrapped with non-conductors, and placed in an accessible conduit of brick or wood, each of which mains constitutes a complete loop, so that its further end returns directly to the boilers, the egress and ingress nozzles being so placed as to increase the natural circulation of the water in the boiler. At distances prescribed by street and alley crossings, but limited to lengths of 100 to 150 feet, are placed expansion joints, being simply castings, bolted to one end of each section, and to a solid block of foundation, into the further end of which enters through proper stuffing boxes a phosphor-bronze sleeve which forms the initial end of the next section of pipe. These castings are so arranged as to take at the same time the expansion joints of a return main to be afterward described, and the cross connections for the intersecting street or alley. Close to them are also placed stop valves to make it possible to cut out one section at a time for repairs while temporarily supplying the district beyond through the next street main, which thus for the time becomes a by-pass pipe.

In each section is also placed a check valve, being a simple spherical enlargement of the pipe, in which a heavy metal ball is so located that it can roll into and close the conical mouth of the pipe to either side as

* Read May 2, 1888.

soon as the fixed maximum speed of the water is exceeded. In case of accident, therefore, or of malicious injury, the two nearest check valves would shut off the injured section, so that the leakage would simply have the effect of flooding the conduit to a depth of a few inches with water, while the steam formed therefrom would be rapidly dissipated at a very low pressure. An explosion cannot occur here, since, in the opinion of the best experts, a good-sized rupture even of the shell of a boiler, when entirely under the water line, will rarely cause an explosion, since water alone, no matter at what pressure, will not readily attain a dangerous velocity. In the case of our pipe we have cooling influences at hand to reduce the effect of such ruptures, while, in the case of a boiler, additional furnace heat is constantly adding to the pent-up energy. At intervals of about 20 feet a coupling is placed, which at the same time is utilized for supplying service boxes placed at the sidewalk. These couplings have special threads, having the peculiarity that the base of the thread is conical, *i. e.*, runs out, while the crown of the thread is sharp and cylindrical. By this means the weakening of the pipe is diffused over a considerable length, so that experiments have shown it possible to preserve 97 per cent. of the full strength of the pipe. Furthermore, this form of thread can be so forced into the coupling as to actually bed the metal of the pipe into it and make an absolutely tight joint, even under the test pressure of 1,500 pounds.

All pipes before being laid are tested to 4,000 pounds pressure; a certain percentage of them, however, are tested to rupture, which generally requires over 12,000 pounds. Each section when laid is again tested to 1,500 pounds and made tight under this pressure, and finally the whole main is tested to 1,500 pounds per square inch. The entire supply pipe or force main rests on rollers supported on cast iron brackets about fifteen feet apart. The same bracket holds under its arched base a return pipe of double the diameter of the pressure main, which rests and rolls on a small iron trolley supported on the base plate, the whole being bolted down to a brick pier. This larger return pipe also forms a complete loop under the pressure main; it has similar joints, couplings, and expansion sleeves. The whole pipe system, after being tested, is wrapped with an asbestos covering, over which is secured a layer of asbestos cloth painted with water-proof paint. Over this, with a liberal air space between, is placed a brick arch, outside of same another air space and still another brick arch, the outside of which is covered with some water-proof cement. The board of experts before referred to found the loss in temperature of a four-inch hot-water main in Boston to be only four degrees for a length of nearly two miles, and that at a minimum speed of the circulating current of one and a half feet per second. The claim of the Boston company that their entire loss by radiation will not be more than two and a half per cent. on the average therefore seems well founded.

From each coupling in the hot main a one-inch pipe runs to the service box located at or under the sidewalk, where by means of a tee it branches into three openings, each closed by an asbestos-packed cock. From this point to the inside of the house wall, generally a distance of less than ten feet, a small copper supply pipe runs to the converter, copper being used to enable the steam fitters to run their pipe in any direction around obstructions to the point where the converter is most conveniently located. These pipes run generally from one-eighth to three-eighth inches in diameter, one inch being a maximum. The converter is simply a steel vessel taking the place, in the house, of the steam dome, which is not required on the boilers at the station. The small copper service pipe terminates in a pressure-reducing valve screwed by a short nipple against the converter. These valves are controlled very nicely and accurately by electricity. To the top of the converter the steam pipe either for power or for the ordinary steam system of the house is attached, being of the same dimensions as if attached to a local boiler. Each converter is further supplied with a steam gauge to show the pressure at which it is set; at its bottom it connects through a return pipe into the service box, and from that back into the return main. As a further precaution a pop safety valve is placed in a horizontal position at the bottom of the converter, so that in case of excess of pressure by a failure of the reducing valve to do its work, the water can be discharged through the safety valve into the return system. Where ordinary steam-heating plants exist in a house the steam pipe from the top of the converter is simply connected with the same, the connection with the boiler being broken. The same applies to the connection of the system to an existing power plant. Where furnaces or indirect heating or ventilating systems are to be replaced a coil of pipes is substituted, either directly from the main with hot water or from the converter with steam. For cooking, a range is used in which a network of these small hot-water pipes is placed so as to give a constant temperature, sufficient for cooking, baking, etc.; in fact, every operation except broiling, and ranging from 350° to 400° F. It will be seen that by using two converters we may first extract from the hot water sufficient steam at 70 or 80 pounds pressure to drive the power plant of a building, and from this pass the water into a second converter to furnish a further supply of steam at a very low pressure, which may be supplemented by the exhaust from the engines to heat the entire building in the coldest weather. I have above considered only the difference in economy between large, well regulated power plants and small, cheap, local ones. When we come to compare the cost of this system with the cost of fuel for domestic heating and cooking purposes we find that only 10 to 15 per cent. of the heat in the coal is there in practice utilized, as against from 50 to 75 per cent. in steam boiler plants. The Boston Heating Company, which has had this system in use on a large scale during the past winter, estimates for ordinary city houses about 1·1 heat unit per cubic foot per hour. I have found in good examples of steam heating in this city a consumption somewhat larger, but as in my case the buildings were used for offices, where on account of almost constant opening of doors a larger loss of heat may be expected, I believe it to be perfectly safe to figure on 2 heat units per cubic foot per hour as a maximum. Of course, this will be much modified by the circumstances of exposure.

If we consider 5 pounds gauge pressure as ample for steam heating on the average, we find that at this pressure our hot water at 400° F. will give us nearly 20 per cent. of its weight as available steam and still have a large quantity of heat left in the other 80 per cent. for indirect radiation, or for heating water for baths, etc. At the pressure mostly used for pumps, elevators, and small engines about city buildings, say not exceeding 70 pounds, the same water will return us about 10 per cent. of its weight as available steam, the other 90 per cent. being further available for the other purposes above mentioned, and, of course, the exhaust from these engines can be further directly applied for warming, ventilation, etc. Practically then a four-inch pipe would, at a speed not exceeding 10 feet per second, be able to completely supply 50 average stores of 25 feet frontage, 120 feet depth, and three stories of each being heated and each supplied with its own elevator. Since, however, a plant of this kind will always run during the whole 24 hours, and, therefore, the brunt of the fight against cold can be borne by the system during the early morning hours before there is any demand for power, we may reasonably expect to get a result fully 20 per cent. better.

Whenever the plants of heating companies under this Prall system become of sufficient size, a great deal of the water from the return becomes available for condensation at the station, thus reducing the cost of running its own pumps, electric light and fan engines. The water, after all its service has been performed, is thoroughly filtered to remove any grease, grit or dirt it may have picked up in its wanderings, and is then pumped back into the boilers by ordinary feed pumps, passing on through the same pipe and mixing with the water which comes back from the return end of the pressure main. The system has been not inaptly compared by its promoters to the Gulf Stream, which furnishes an example of the great distance to which water can carry heat, thus making the tropical sun of the West Indies exert a genial effect on what would otherwise be the glacial coasts of Northern Europe. When a new main is first put into service, the hot water is pumped through it at a low speed, and this is continued until the conduit and its surroundings are well dried out, and the minimum speed for that main is then fixed by the rule that the last consumer, *i. e.*, the one nearest the station on the return end of the loop, is entitled to a temperature of not less than 390°. When the house connections are afterward all made, while the inflow of the pipes will be at a much greater rate of speed, as long as the return end of the loop maintains this minimum speed the last consumer will be practically as well served as the first. Each station contains apparatus for measuring and recording temperatures and pressures of the boilers, of the outgoing and incoming main, and of the return main. An inspection of the Boston plant in its everyday working must convince the most skeptical that the solution of the heat and power problem of modern municipalities has been found, and that a continuance of the same methods of thoroughness will advance this solution still further, and probably soon fix the limits of such systems in all directions as concisely as they have been fixed for our ordinary gas and water supply. While the great first cost of such a system will in every city limit its first application to the most thickly built-up portion, and therefore to the business section, its advantages will there become so palpably manifest that such central stations will gradually be found supplying the best settled residence districts also, especially since the margin between domestic economy in fuel and that possible in such a station is much greater than that existing between it and ordinary isolated steam power plants in the business section.

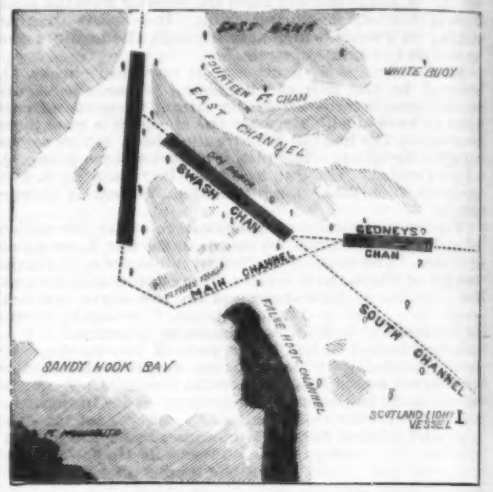
One fact bears strong testimony alike to the correctness of the system and the thoroughness with which the chief engineer of the company, Mr. Arthur V. Abbot, C.E., has done his work in every detail of design and execution. As soon as the first two boilers (Heine patent) were put in position, a steady circulation of warm water was forced throughout the entire main, the temperature gradually increased up to 380°, and next a solution of potash was pumped into the main and circulated for several days to remove all traces of grease and red lead. Then this hot potash water was replaced by fresh warm water until no more signs of contamination existed. During about ten days consumed in this manner, the whole of the line was carefully watched as to leakages and the working of the expansion joints. Thereupon house connections were immediately made and heat and power supplied during the entire winter, without an hour's interruption from any cause whatever, during which time eight more boilers were successively placed in service. Parties using the steam testify to its being unusually dry. When snow was on the ground, there was no sign of its melting faster over the conduit than in other parts of the street, except at the manholes, which are simply covered with two plates with an air space between them. —*Jour. Assn. of Engineering Societies.*

THE IMPROVEMENT OF NEW YORK HARBOR.

One of the most important operations ever conducted by the United States government, from a commercial point of view, is now in process of execution. We allude to the improvement of the channels leading up to New York City from the ocean. In one of his messages to the Board of Aldermen, Mayor Hewitt alludes to this work briefly, emphasizing its great importance to the residents of this city. With the increased length and depth of ocean steamers, it has become very evident during the last few years that something must be done, unless commerce is to be diverted from New York, or, at least, its expansion modified by the restricted depths and widths of the channels. While the question of depth affects the construction of the vessels directly, the narrowness of the channels has rendered necessary quick turning, so that the long type of vessels now in greatest favor for ocean navigation have found great difficulty in getting in and out of the harbor. They have been obliged to arrange their periods of starting by the tide, and very frequently are forced to wait outside of the bar until high water, if they reach it at any other than that period. It has been obvious for many years that some improvement was required, and little prescience was required to see that the necessity for such improvement was increasing in importance.

In 1884, an appropriation of $200,000 was made by Congress under the river and harbor bill, to be devoted to "the improvement of Gedney's channel, New York harbor." In order to work intelligently on so complicated a problem, Col. G. L. Gillespie, of the United States corps of engineers, then in charge of the New York district, was directed to make a survey of the whole harbor of New York. This was done by order of the Secretary of War through the chief of engineers.

The survey was commenced in August and completed in December, 1884, and reflects great credit on Colonel Gillespie, as well from its thoroughness as from the short space of time in which it was done. Soundings were taken by lead line from a tug boat which was kept in constant motion over the ground. Every half minute a sounding was taken and recorded, and every second sounding was located by sextant observations referred to fixed points on shore, whose geographical positions had been determined with great accuracy. With regard to the exactness of this method as compared with rod soundings, comparative tests have been



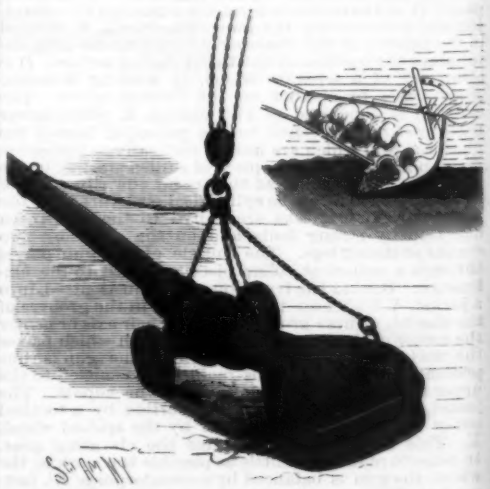
CHANNELS OF NEW YORK BAY.

made where part of the ground has been gone over by both, and it has been found that the rod soundings show a less depth than the line soundings by an average of six inches. A fourteen pound lead was used, and the line was compared at frequent intervals with a steel tape in order to verify its accuracy, and when not in use was kept lying in fresh sea water. The object of the survey was not only to determine just what was to be done to improve the harbor to the greatest advantage, but it was also designed to ascertain whether any shoaling of the channels had taken place.

The results obtained in this 1884 survey were compared with the first accurate coast survey made in 1835, nearly fifty years before, and no shoaling whatever during this period of years was shown, and it was proved that a 23 foot channel had been maintained by the natural scour of the ebb tide.

It was not certain, however, that a greater depth could be maintained, and therefore Colonel Gillespie, while advocating dredging the channels to a depth of 30 feet at mean low water, with a width of 1,000 feet, stated that in all probability the only way to maintain a 30 foot depth would be to contract the tidal prism by means of a dike starting from Coney Island and running toward Sandy Hook in a general southwesterly direction, on the ground that the contraction of the tidal prism would increase the ebb scour.

Colonel Gillespie's report was referred to the board of engineers for fortifications and rivers and harbors, who generally concurred in Colonel Gillespie's plan. It was proposed to leave an opening in the dike for the



DREDGING SCOOP AND SUCTION PIPE.

Coney Island channel, which is, to a large extent, used by the Coney Island and Rockaway steamboats and by oyster smacks and other small vessels from the Great South Bay and other points on the shore of Long Island. Such a dike would close the 14 foot and East channels. But these two are avenues of comparatively little importance, and their closing would be fully justified were the Main channel and Swash channel thereby benefited.

Estimates were made of the expense of improving Gedney's and the Main ship channel, placing it at about $1,000,000; but as this did not allow for the increase of 30 per cent. due to scow measurement of dredgings, because it referred to material in place, the total cost of this estimate rises to $1,370,000.

As the act appropriating the $200,000 specifically stated that it should be applied to Gedney's channel, bids were asked for to do the work there, and it was commenced by hydraulic excavators, with large centrifugal pumps, which raised the material from the bottom. These excavators were not self-propelling. A tug boat was used to tow them up and down the channel. By their use a general increase of two feet in depth over a width of 1,000 feet was obtained. Before this first appropriation was exhausted, a new appropriation of $750,000 for general improvement of New York harbor was voted, August 6, 1886. The matter of the expenditure was referred to the board of engineers, who decided to apply the appropriation to dredging only, as it was not thought that the dike was needed, for the present, at least, as in any event the channels would have to be deepened.

We illustrate the apparatus now in use by the Joseph Edwards Dredging Company, who are the sole contractors under this appropriation. Their fleet of vessels comprises three propellers, each fitted with two Edwards centrifugal pumps and two dredging scoops connected by pipes with the pumps. Each vessel is divided by bulkheads into tanks for the reception of the dredged material. In the bottom of each of the tanks are valves, worked by horizontal valve wheels. By proper conduits the dredged material can be delivered to any one of the tanks, according to the way in which the chutes are set.

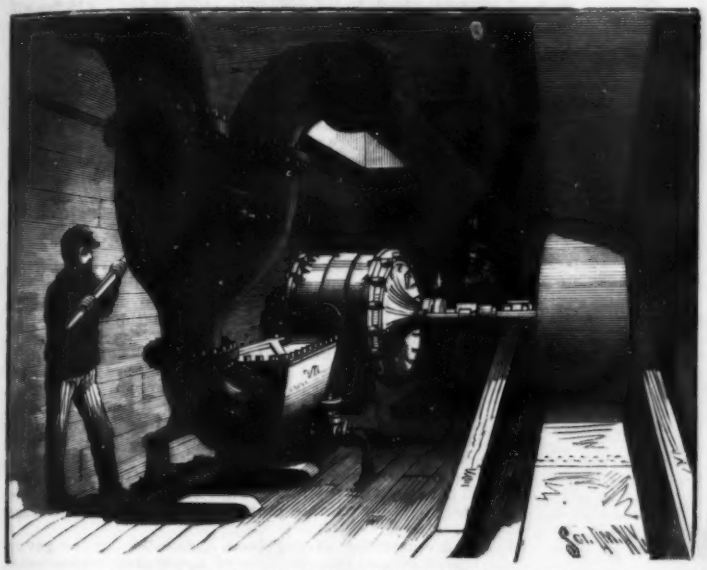
The estimated capacity of the plants per working day are: No. 1, 2,000 cubic yards; No. 2, 1,500 ditto; No. 3, 3,000 ditto; giving a total capacity of 6,500 cubic yards. All the material is taken outside of Scotland Lightship and dumped at a distance of about 8 miles from the main ship channel and 5 miles from Gedney's channel, in not less than 14 fathoms of water.

The general operation is as follows: The scoop is dropped down to the bottom, on which it runs upon wheels. The pipe which connects it to its pump is of steel, containing a ball and socket joint and including also a short length of heavy India rubber pipe re-enforced with steel bands, in order to prevent breakage when the vessel is rolling or pitching in a seaway. By means of a steam jet connected with the top of the centrifugal pump, a vacuum is produced within the pump and pipe, under the effects of which vacuum water rises through the pipes until the pump chamber is completely filled. Then, on starting the pump and opening the outlet valve hitherto closed, it at once begins to draw up material. At the upper surface of the scoop, a foot or so above the bottom of the water, a water valve is arranged which may be opened or closed by means of a small rope or lanyard. This is done from the deck of the propeller, and regulates the proportions of water and solid material. The operative can tell by the sound of the pump whether it is receiving too much or too little solid material, and sets the valve accordingly.

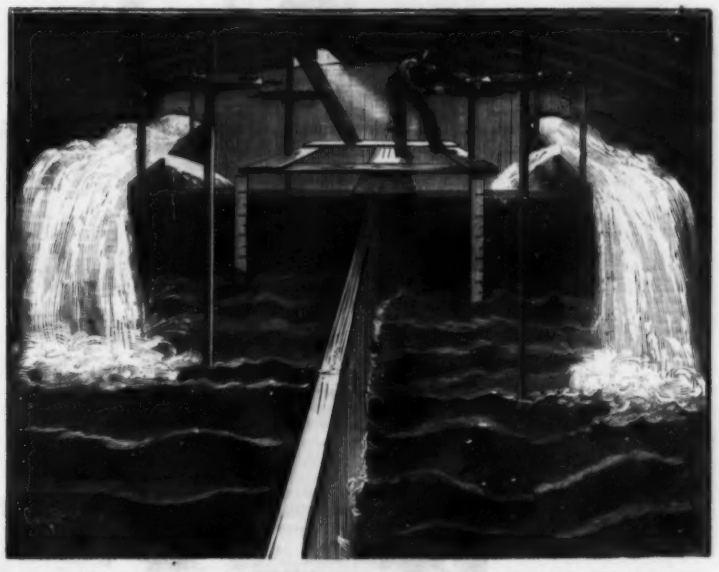
In dredging, the boat is made to advance at the rate of from one-half to two miles an hour, while both pumps are driven as fast as may be. It is very important to drive them to their full capacity, as they possess a critical speed below which their efficiency is greatly reduced. The boat thus travels down the channel, dragging with it the scoops, which are continually raking up the ground, which, as fast as it is loosened, is drawn up through the pipes by the pumps. The suctions are attached to the side of the boat about midship, so that they are unaffected by pitching, while, owing to the great width of the boat, its rolling is so slight that they are not thereby disturbed.

At the present time a 600 ft. channel of nearly a uniform depth of twenty-six feet has been secured through Gedney's channel. The several soundings of the channel were located in the most accurate possible manner. Tripods, or other fixed stands, were erected in the water on one side of the survey, on which platforms were mounted. Upon these transits were placed, with attendant engineers. A boat was then allowed to drift down the channel within a given range, with the tide, and soundings were taken from her stern with a pole terminating in a flat plate of iron, to prevent penetration of the bottom.

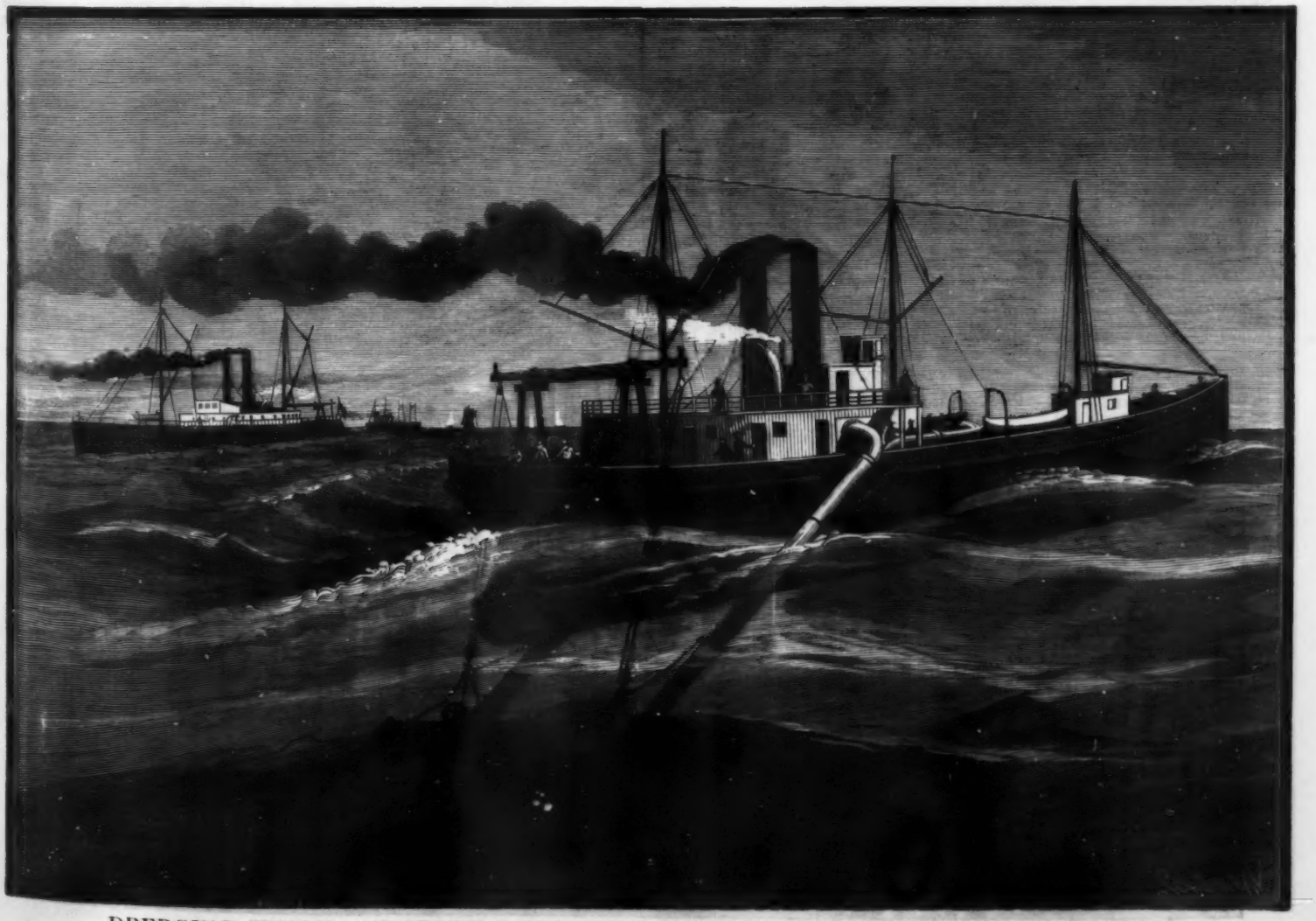
As each sounding was taken the signal was given and the spot was located by transit observations. The geographical position of each of the tripods (or transit stations) had been accurately located beforehand,



CENTRIFUGAL PUMPS AND CONNECTIONS.



THE TANKS AND DISTRIBUTING SYSTEM IN THE HOLD OF THE DREDGING VESSEL.



DREDGING VESSEL AT WORK DEEPENING THE CHANNEL IN NEW YORK HARBOR

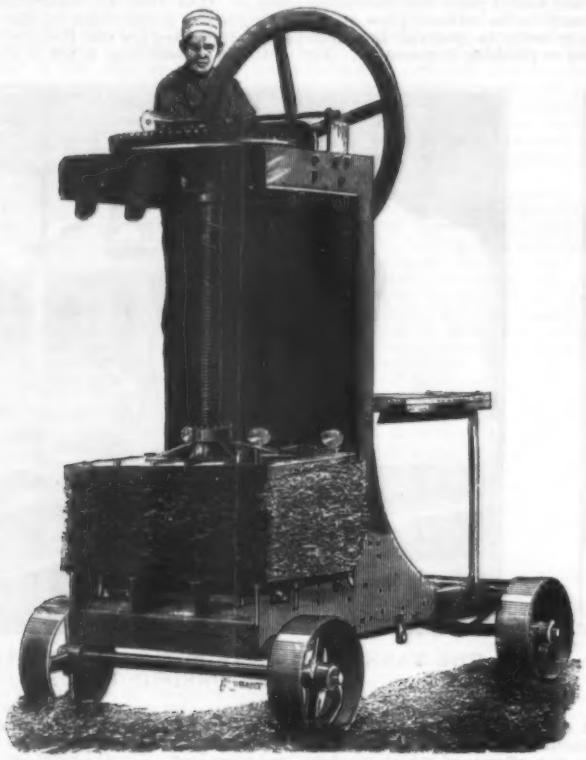
which eliminated any possibility of error. This survey was executed during the fall of 1887, and is a monument of hydrography. It is proposed to execute a second survey of similar character, in order to ascertain whether any change has occurred during the winter storms. A survey made at the close of the work, in December, 1886, and another made before work commenced, in the summer of 1887, showed that, instead of shoaling, Gedney's channel had slightly deepened during the winter.

As the work is now being executed, there is every promise that in a short time the harbor of New York, as regards approaches, will be excelled by no harbor on the Atlantic coast, as it is excelled by none in the world in the anchorage and shelter it affords vessels when they have once entered it.

Up to the end of 1885 this work was in charge of Colonel Gillespie, corps of engineers, who is now stationed in Boston, and who was succeeded by Colonel Walter McFarland, corps of engineers, who is at present in charge.

WARNES' HAY AND STRAW PRESS.

THE hay and straw press which we illustrate is the one which gained the second prize in the class of hand presses at the late show of the Royal Agricultural Society. It was exhibited by Mr. William Warnes, of King's Lynn. The most noticeable feature in it is that the pressure between the platen and the table is not taken by direct ties, but is transmitted through a steel framing of considerable strength. The platen is moved by a screw, the nut of which is rotated by bevel wheels. There are two pairs of wheels; one for slow and one for fast speed are employed, the connection to one or the other being made by a clutch. Side doors, between which the material for the truss is packed, may be added. The table of the machine also forms the table of a weighing machine, and by this device trusses of exact weight can be produced, which is a great convenience to small dealers.—*Engineering.*



WARNES' HAY AND STRAW PRESS.

PEREKOP CANAL.

RUSSIA has begun with the perforation of the strait of Perekop, which connects the Crimea with the Russian continent. The canal is to go from Perekop to Goutschar, Sivash, and Genitschesk, and is to be 111 versts long. It will be 65 feet broad and 12 feet deep—at each end of the canal a port will be built. It is stated that the 85,000,000 rubles necessary for the undertaking have been found. The shortest road from Genitschesk to the northern ports of the Black Sea will be through the new canal. The voyage from Odessa to Maripol is at present 434 sea miles long; through the canal it will be only 295. The work will take five years. Once the canal is finished, it will be easy for Russia to send her ships from the Sea of Azof to Otschakow, to the mouth of the Dnieper, and to Odessa, because they will no longer have to sail round the Crimea, and will not risk being captured by foreign ships in case of war. The chief reason for building the canal is the necessity for getting coal from the Don districts for the Russian fleet.—*London Economist.*

NEW POST OFFICE BUILDING, PARIS.

THE new Post Office building at Paris, which has been finished for several years, and the inauguration of which has had to be postponed so many times, has been finally delivered to the Department by the Administration of Public Buildings. It will be remembered that the delay has been exclusively due to the bad performance of the elevators. These, as the edifice is several stories high, constitute an essential element of the general working of the principal services. It is through the intermedium of them that are distributed in the various sorting and classifying rooms all the packages of letters or printed matter that are brought by wagon to the courts on the ground floor. There are two distinct groups of elevators, one of them set apart for printed matter and the other for packages of letters.

A committee of engineers appointed by the government judged the old style of apparatus impracticable, and adopted the project presented by Engineer Barbet and Col. De Bange.

As a large battery of Belleville boilers had already been put in for running the old elevators, the committee ordered that these generators should be utilized for actuating the new apparatus.

Since steam is a very elastic fluid, it could not be made to act directly upon the elevator. Instead of employing transmissions of motion with gearing, Mr. Barbet conceived the idea of interposing between the steam and the elevator a column of incompressible water, which permits of obtaining exact stoppages, just as in ordinary elevators. This was the system presented by the Cail Works and adopted by the Committee.

Each of the two groups just mentioned consists of six elevators arranged in threes and parallel with each other. In the shaft of each there moves a car guided from top to bottom by iron bars and actuated by the system that we are about to describe.

Beneath each elevator there is installed a multiplier consisting of a steam cylinder and a hydraulic cylinder

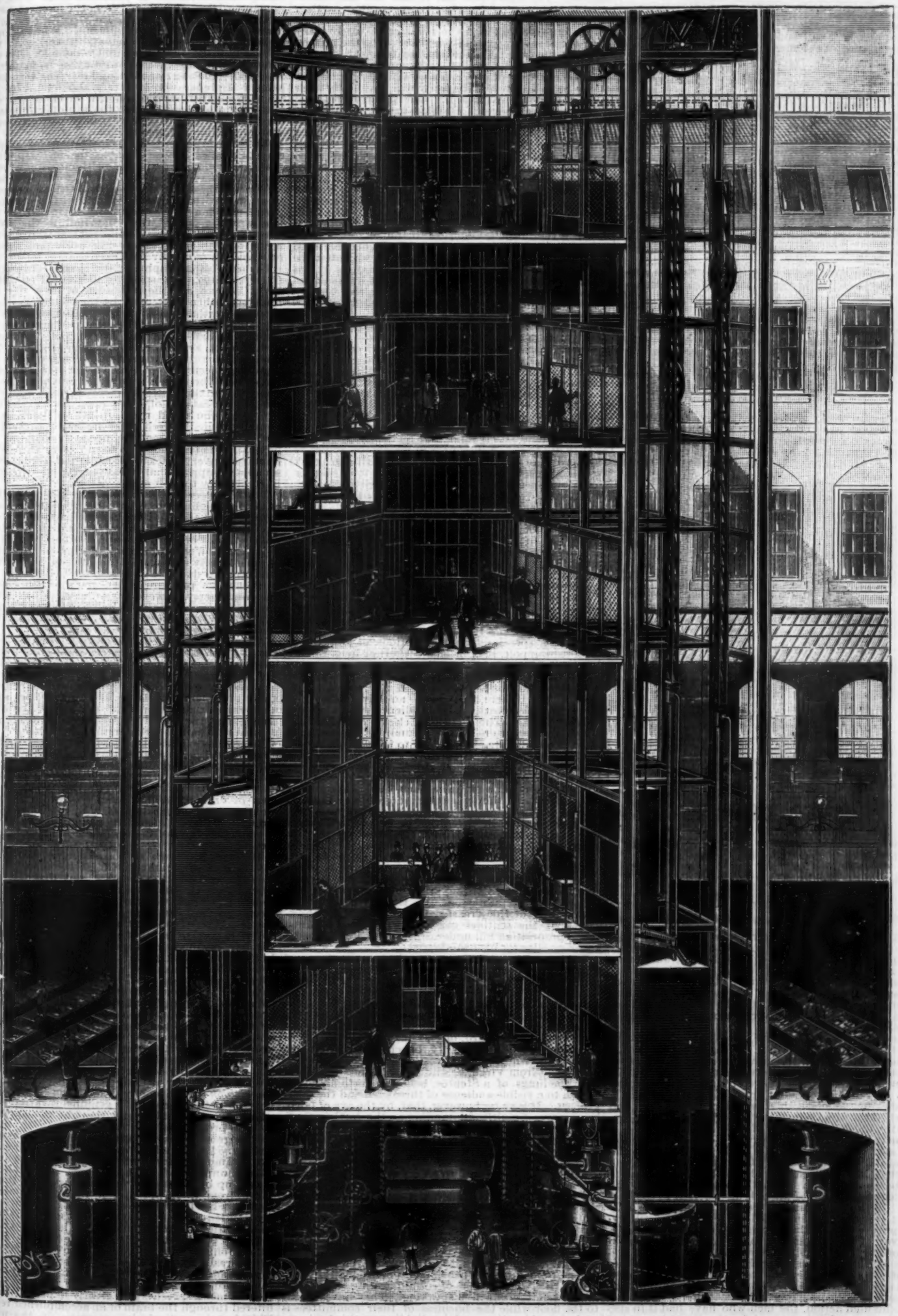
THE NEW POST OFFICE, PARIS.

connected with each other by bolts. In this double cylinder moves a piston which rests beneath, through its small section, on a column of water and receives the steam on its wide section above, the surface of which is hardly double that of the other.

When the steam is introduced, it drives down the piston, which forces the column of water into a pipe connected with a hydraulic press formed of a cylinder and a piston whose rod carries a pulley. Over this latter passes the cable, which, after passing over a stationary pulley at the top, supports the car. This latter is provided with a parachute, as in mines, in order to prevent accidents.

When the piston of the hydraulic press descends, the car rises double the distance. In order to make the car descend, it suffices to let out the steam contained in the upper cylinder of the multiplier. The column of water being no longer under pressure, the piston of the hydraulic press rises under the action of the car's weight, which is balanced by that of the piston of the multiplier. In order to keep the car in a stationary position, it suffices to close the cock of a distributer placed at the lower part of the pipe leading to the press.

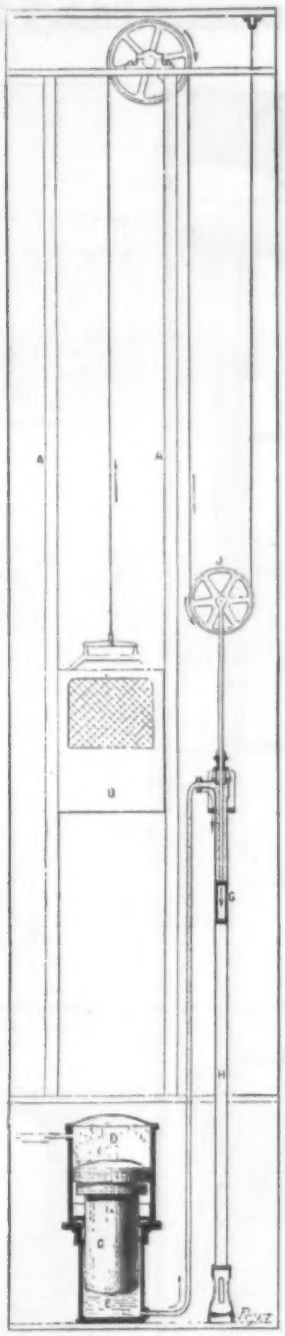
Each elevator is operated by means of an endless cable whose extremities are fixed to the wheel that maneuvers the distributer. Stoppage is effected by



ELEVATORS IN THE NEW POST OFFICE, PARIS.

means of tappets fixed to the cable and which meet other tappets fixed to the cars. The latter consist of osier baskets rolling on rails and each weighing from 330 to 440 lb.

This system of elevators, we believe, is the first in which a direct application of steam has been made.



The elevators have now been running regularly for a month, and are giving complete satisfaction.

We present herewith, from *L'Illustration*, an external view of the building.

[The Writer.]

PREPARATION FOR SPEECH MAKING.

Clergymen, as a rule, now enter the sacred desk with their discourses in hand, thoroughly prepared. When politicians become equally honest, and carry their manuscript with them, we shall have better and fresher speeches from the stump. The loud-mouthed political orator who boasts of having made a hundred speeches in the campaign, simply misstates a fact. What he did was to deliver one speech a hundred times.

Some few persons who have not yet become reconciled to written sermons are apt to refer to George Whitefield, the great field preacher of England, as an untaught, natural, and inspired orator. The truth is, however, that Whitefield never trusted to the inspirations of the moment, but from his boyhood was a painstaking, indefatigable preparer of speeches, and preached the same sermons over and over again—frequently, indeed, as often as fifty times.

It may be asked, "Do the great debaters in legislative and deliberative bodies make laborious special preparation?" Invariably. Theirs may not be written speeches, but if they are at all worthy of preservation it is because they have been thoroughly prepared. In our legislative bodies all bills are referred to committees. In these committees they are discussed item by item; every word is subjected to the closest scrutiny. The purpose of the bill is considered; the arguments in favor of its passage are carefully weighed; the objections to it are forcibly presented. The effect of previous legislation of a similar character in this and other countries is ascertained, and after the lapse of many days or weeks, when the bill is at length reported back to the House, Senate, or Parliament for its consideration and final action, the men who have had it in special charge are fully prepared for the discussion; what may then seem to be the impromptu utterances of the moment are, in fact, the result of days and weeks of deliberation, during which libraries have been ransacked, precedents examined, and statistics carefully collated.

The political oratory of the United States for the first half of the present century, if we except the speeches of a few well-known statesmen, had in it little, if anything, to commend it to the student. The addresses were, as a rule, delivered to out-door assemblies composed of men whose education had not been such as to render them critical as to either matter or manner. The orator had full license not only in respect to statement of fact, but in every other particular, for the art of stenography had not reached that perfection which enabled the reporter to catch every word of the speaker and fasten it forever on the printed record of the time. To the uneducated hearer a ludicrous but indelicate anecdote, a humorous but coarse expression, a torrent of slander, or a flight of grandiloquent but meaningless rhapsody was frequently more satisfactory than would have been the polished and witty periods of Wendell Phillips or the argumentative discourses of Daniel Webster.

We occasionally find now, on the stage of political action in the West, a fossil of that old time. He has been delivering the same address for half a century, with such slight changes in it from year to year as would reconcile it to the times. His speech has never appeared in print, because it contains nothing worthy of publication. Indeed, in cold type it would be recognized at once as an absurdity, and yet it still finds those who applaud its successive repetitions, and insist that it is the sublimest effort of the human mind.

A carefully prepared speech of fifty or one hundred years ago upon the issues of those times will often be found as applicable and pertinent to-day as it was then. Lord Chesterfield's speech against licensing gin shops would be as fresh and relevant in the General Assembly of Ohio as it was in the British Parliament in 1743.

Fifty years ago in the United States, and one hundred years ago in England, men made elaborate speeches on tariff, free trade, taxation, economy in national expenditure, the currency; the relations of capital to labor; the duties and responsibilities of the citizen; the obligations of the government; the education and elevation of the people; official integrity; the maintenance of the national honor; civil and religious liberty; the evils likely to result from an infraction of the constitution. With slight changes those old speeches would satisfy a popular audience as well now as they did then. A discourse in which the topics referred to were treated separately, and with care, could be made to serve the average politician for a lifetime. For a long speech, the whole might be delivered; for a ten minute effort, either one of the points suggested would answer; for variety, the different parts might be shaken up in the orator's hat and delivered in the order in which they were taken out. If kept from the newspapers, only the eloquent gentleman's most intimate friends would discover that he was delivering the same speech year after year. I might mention at least one distinguished and successful statesman who has been repeating the same identical speech for ten years. If serenaded to-night he would find some portion of it applicable to the occasion, and thus astonish his hearers by the fertility of his intellect and the readiness with which he could respond to an unexpected summons. His speech is built in sections, or joints, and, like a fishing pole, may be made short or long, to suit the waters in which he is angling.

The stupid men in a legislative body often render themselves the most conspicuous in the record of its proceedings. There they have an advantage they never enjoy elsewhere. Their audience cannot wholly abandon them. The chairman, clerks, door keepers, pages, and reporters, if not bound by their official oaths to remain, are at least held to their posts by desire for their monthly stipend. I have in mind now one member of the national House of Representatives who insisted upon getting his name in the *Congressional Record* at least once each day. He could do this, indeed, by simply asking a question; but, unluckily, his ambition was not always so easily satisfied. It is quite certain, however, that he never made a valuable suggestion to the House. Another member acquired a national reputation by objecting, as he had a right to do under the rules, to the introduction of bills, amendments, and resolutions out of their proper order. He was known as "The Great Objector." Another became famous by fighting propositions involving the expenditure of public money. He was called "The Watch Dog of the Treasury." It was observed, however, that the sentinel generally went to sleep when the appropriation bill under consideration contained a generous slice for his own district.

The anxiety of members to make speeches is one of the greatest obstacles to the rapid and efficient dispatch of public business. The representative feels that if he does not take part in the debates his constituents may conclude that he exerts no influence in the moulding of legislation and the conduct of public affairs To satisfy them, and thus perpetuate himself in office, he thrusts himself forward, often reluctantly, indeed, and delivers speeches to empty benches or inattentive ears. I have now a lively recollection of a ponderous gentleman from Virginia, who in an evening session, with the lungs of a Stentor, bellowed forth an hour's speech to a visible audience of three men and the doorkeepers. It may be, however, that, by the eye of faith, he saw a vast multitude standing on the further shore of the Potomac, thrilled by his magnificent flights, and enthusiastic in their indorsement of what he said. He certainly yelled like one who was bound to make them hear.

It is not at all unusual to see a member on the floor of the national House of Representatives, gesticulating like a madman, thundering away at the top of his voice, and perspiring like a haycock after a shower, while no one of all the three hundred gentlemen present accords either to himself or what he says the slightest attention. They understand, of course, that his speech is for home consumption, and that our political system renders it necessary for even the wisest of men to make fools of themselves occasionally.

As a rule, the members of certain leading committees do most of the effective speaking. They have a right to the floor while the business of their committees is under consideration, and by dividing up this business, and parceling out the time among themselves and their friends, they manage to confine the discussion within reasonable limits. It would be a mistake, however, to suppose that the good speeches delivered in that body are unstudied efforts, or that the impromptu utterances are one whit superior to the ordinary interchanges of thought occurring among educated men in business and social circles throughout the country.

Some personal quarrels have taken place between members of Congress, in which much adroitness in repartee and eloquent invective were noticeable. But even these sudden and brilliant encounters were never wholly unanticipated. A politician is as quick as a woman to detect a rival, and from the moment he suspects there may be danger ahead, begins to make preparation to annihilate his opponent. When the quarrel is ripe, therefore, the combatants spring to their feet ready to do their best, and what may seem to be a sudden and unexpected inspiration is, in fact, the final blaze of a long smouldering fire. The very knowledge that preparation for attack and defense has been made frequently prevents a violent outbreak; for when both parties are proficient in the art of vituperation, neither can hope to emerge from a personal conflict with reputation unimpared.

While the arguments and illustrations of a speech may be recalled by one who has listened attentively, there are few, if any, who can, without a knowledge of stenography, reproduce the speech, word for word, as it fell from the lips of the speaker. Others may report the matter with substantial accuracy in their own language, and in a style as peculiarly their own as their handwriting; indeed, they may imitate the style of the orator, just as they may his penmanship, but these imitations will be either better or worse than the originals, and consequently imperfect.

The art of stenography, or shorthand, was unknown sixty years ago. The speeches attributed to Webster, Clay, Calhoun, and the statesmen of their day, were, therefore, either written out by themselves, or they are in some part, at least, the production of other men. The same is true, also, of the great parliamentary leaders of England—Chatham, Burke, Fox, the younger Pitt, Curran, Erskine, Sheridan, and Grattan. There was, in their time, no person in all England who could reproduce accurately a long speech after hearing it but once. The speeches purporting to be theirs were, therefore, either written out by themselves, or they are the fabrications of other men. It is evident that an orator who could recall, in all its details, a long, unpremeditated speech after he had recovered from the exhaustion consequent upon its delivery, must have had such a memory as would have enabled him to master it very quickly before, and it is far more reasonable to suppose that it was reduced to writing prior to its delivery than at a later period.

The first speech of Daniel Webster in reply to Hayne, of South Carolina, has often been referred to as an unpremeditated effort. But Calhoun had some time previously affirmed the right of an individual State to nullify an act of Congress, and it is hardly possible to believe that Webster, in view of this fact, would fail to make timely and ample preparation to combat so dangerous a doctrine whenever an opportunity to do so should be presented. Webster's second speech in this controversy, however, was the most brilliant and able he ever made in the United States Senate, and no one, I think, has ever disputed the fact that it was thoroughly prepared before delivery.

We have been told that Governor Corwin's humorous reply to General Crary was an impromptu effort, but Corwin himself more than once asserted that he was thoroughly prepared on that occasion. He had but recently written an article on the military achievements of General Harrison. It was therefore an easy matter to recount the martial services of the old veteran and, at the same time, ridicule a cornstalk militia general who had undertaken to belittle them.

No one has ever doubted that the great orators of Greece and Rome prepared their orations—wrote them out in full, and committed them to memory. Indeed, they were probably perfectly memorized when fully written and revised, for it would be impossible for a man of ordinary ability even to devote weeks and months to the preparation of a discourse, as we have reason to believe Demosthenes did, without having it so thoroughly rooted in his mind as to make the manuscript unnecessary. But, notwithstanding all the facts to the contrary, there still exists a popular delusion that the orator's brightest and most eloquent sentences are inspirations of the moment, and that for him no special preparation is ever necessary. A victim to this belief, who heard Colonel Robert Ingersoll during a recent political campaign, followed the distinguished orator to his next appointment, and was both surprised and chagrined to find that he repeated the same speech, without the omission or addition of a single syllable. In short, the speaker's wit, pathos, and argument had been studiously prepared and committed to memory. When the late Salmon P. Chase was a candidate for governor of Ohio, he delivered the same speech from twenty or thirty different stands, and finally allowed it to be published in the *Sandusky Register*.

Orators who do not prepare their speeches have been known to steal those prepared by others. During the war a gentleman of central Ohio obtained a fine reputation in his immediate neighborhood for eloquence and good sense by delivering a speech of D. S. Dickinson. One member of Congress might be named whose speech was almost wholly stolen from Rufus Choate. It was a good speech, and a genuine surprise to those who knew the member and thought of course it was his own production.

Stenography has had a wholesome effect on popular oratory. Men who have any regard for their standing in a community cannot afford to go before an audience wholly unprepared. Their words are liable to be picked up by the ready writer so soon as they have fallen from their lips, and if they talk nonsense, or make fools of themselves otherwise, they will be so represented to the world in the next morning's journal. Indeed, the audience outside the hall may be almost infinitely greater than that on the inside. A speech which John Sherman may deliver to two hundred men will be read and criticised by two hundred thousand. Careful and painstaking preparation has therefore become absolutely necessary.

Some men's speeches are greatly improved by being filtered through the brain of an accomplished reporter. This fact is particularly noticeable in the national House of Representatives. If an absolutely accurate

report of the debates in Congress were made for one week, either the reporters would meet with a sudden and violent death or the publication of the *Record* would be suspended. Even after the reporter has improved the speeches, they are often revised time and again by the orators themselves before the matter is stereotyped; and then the plates are sometimes corrected before the volume is finally published.

The orator who has his speech thoroughly in hand delivers it with an ease which astonishes those who have no knowledge of the time and labor expended in its preparation. It has been said of Lincoln that he always argued his opponent's side of a case in his own study before going into court. In this way he anticipated every argument that could be made against him, and was ready to meet it promptly and forcibly in the trial. A man thus thoroughly prepared is not only in condition to reply to any question that may be propounded, but he is free to avail himself of any accidental occurrence or local incident that may serve to add spiciness or interest to his speech. No one, in short, is better prepared to make those unexpected turns of thought which startle and delight than one who is perfectly at ease with respect to the body of his oration. On this point Lord Brougham said: "Preparation is quite consistent with the introduction of passages prompted by the occasion; nor will the transition from one to the other be perceptible in the execution of a practiced master."

In all the famous speeches of the world we find internal evidence of laborious special preparation. Take any of the better passages of the speeches of Burke, Fox, Pitt, and others, and you will see that they could no more have been constructed in the brief time required for their delivery than a watch or clock could be. It is probable, indeed, that the scheme or plan of the oration flashed upon the orator's mind in an instant, just as the first conception of a great painting thrilled like an electric current through the soul of the artist; but both orator and painter were compelled subsequently to labor in preparing and perfecting their ideals.

JOHN BEATTY.

[AMERICAN CHEMICAL JOURNAL.]

THE ATOMIC WEIGHT OF ZINC AS DETERMINED BY THE COMPOSITION OF THE OXIDE.

By H. N. MORSE and W. M. BURTON.

ABOUT five years ago, one of us, with Dr. E. H. Keiser, began a series of experiments upon the preparation of pure zinc, the object in view being a redetermination of the atomic weight of that element with the metal as a starting point. Other methods of preparation having proved more or less unsatisfactory, we determined to attempt the fractional distillation of the metal in a vacuum. We were not then aware of the work of A. Schuller * or of E. Demarcay † upon the distillation of substances in a vacuum. Having found by preliminary experiments made with the ordinary commercial zinc that the method was likely to prove very effective for the separation of the metal from the impurities which are usually associated with it, especially lead, we provided ourselves with a supply of the material which Dr. Schuchardt, of Goerlitz, designated in his catalogue of chemicals as "Zincum met. absolut. chem. pur. (für forensische Zwecke)." This was found to contain a small amount of lead and a trace of cadmium, but no other impurities. From it the pure zinc employed in our determinations has been prepared. After Dr. Keiser's removal to Bryn Mawr, the work was continued with the assistance of Dr. C. Piggot, who distilled the metal, analyzed the various fractions, and also made some preliminary practice determinations of the atomic weight. The authors of this paper are much indebted to both of these gentlemen, since the experience gained while they were associated with the work, and the suggestions offered by them, have enabled us to quickly bring the method into its present simple and satisfactory form for the final determinations.

The method adopted consists in the conversion of the zinc into nitrate, the evaporation of the excess of nitric acid, and the partial decomposition of the nitrate in a hot air bath, and, finally, the ignition of the oxide to constant weight in a muffle. The simplicity and directness of the method are strong points in its favor, and we believe we have demonstrated beyond a reasonable doubt that the objections to it offered by Marignac ‡ are founded on misapprehensions.

I.—THE PREPARATION OF PURE ZINC.

The distillation of the zinc was effected in hard glass tubes of the size of those ordinarily employed in the combustion of carbon compounds. Fig. 1 represents

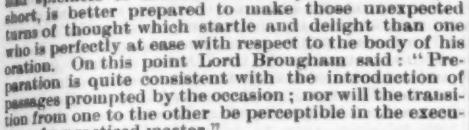


FIG. 1.

their form when ready for distillation. A tube about 600 mm. in length was fused together at one end, and from 150 to 170 grammes of zinc introduced. At two points, *a* and *b*, the glass was softened in the flame of the blast lamp, and depressed by means of a red-hot file, thus dividing the tube into three compartments, which we designate as A, B, and C. The open end of the tube was then drawn out and turned down in the manner indicated. At *c* it was connected with a Sprengel air pump having a manometer attached. The attachment of the tube to the pump was made by means of rubber tubing firmly tied with waxed shoemaker's thread, and surrounded by mercury. The outside of the rubber connecting tube was washed with a solution of mercuric chloride in order to bring about a closer adhesion of the mercury. The use of glycerin joints was found to be impracticable because of the action of the vapor of zinc upon that of glycerin, by which the oxide of zinc was formed, and volatile substances were liberated whose presence rendered a high degree of exhaustion impossible.

The tube having been thoroughly exhausted was then heated in a combustion furnace throughout nearly its whole length, but most strongly in the compartment A, containing the zinc, and least strongly in the compartment C. When raised to its fusing point the zinc begins to distill quite rapidly from A into B, and more slowly from B into C. The vapors from A condensed in B in the form of globules upon the glass, which when they had attained sufficient size ran down upon the floor of the tube, giving when cooled a thick bar of the metal having the form of the lower half of the tube. Those globules which were left upon the upper portion of the tube when the heat was turned off solidified into beautiful but apparently very complicated crystals. When the metal in A had been reduced to about one-fourth of the quantity originally taken, and about one-tenth of the whole had distilled into C, the distillation was suspended. The tube usually cracked on cooling, but not until the temperature had fallen so low that there was little danger of oxidation of the zinc resulting from the admission of air. The portion remaining in A and that which had collected in C were rejected. The portion collected in B was four times redistilled in the manner described. The material deposited in B during the fifth distillation was employed for the determination of the atomic weight. It was carefully analyzed, but we were unable to find in it any impurity whatever. It was also spectroscopically examined by Mr. J. S. Ames, fellow in physics in this university. The following is a copy of his written report:

"I have examined spectroscopically three specimens of the zinc prepared by distillation in a vacuum. The apparatus used was Prof. Rowland's induction coil, driven by a Siemens alternating dynamo, and his 20-foot concave grating spectroscope. Photographs were taken in the ultra-violet from w. l. 4,000 to w. l. 2,000, with wide slit and unusually long exposures. In this region are many of the strongest lines of such metals as lead, cadmium, tin, and indium; and in a specimen of so called C. P. zinc several lines belonging to each of these metals were found on the negatives. With the zinc prepared by distillation in a vacuum, however, not a trace of any of the above impurities could be found."

The rejected portions in A and C were also analyzed, but we were not able to find any impurities in them, except after the first distillation, when the contents of A were found to contain a small amount of lead, and those of C a trace of cadmium.

II.—THE PREPARATION OF PURE NITRIC ACID.

It was found impossible by distilling from a platinum retort to prepare an acid which on evaporation would not leave a residue. The distillate contained in every case a small quantity of gold which the acid had extracted from the solder used in joining the tube to the body of the retort. We therefore made use of the following simple arrangement, Fig. 2. Two platinum

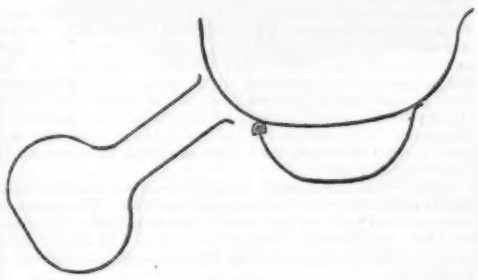


FIG. 2.

dishes, one 100 mm. the other 70 mm. wide, were arranged as shown in the figure, the two being kept apart by hooks of thick platinum wire hung over the edge of the lower one. The upper one was cooled by putting into it pieces of ice. The acid, having first been treated with nitrate of silver, was then slowly distilled from a small flask so placed that the vapors issuing from it would strike against and condense upon the cold surface of the upper dish. The acid thus obtained left no residue on evaporation. It was preserved by placing the smaller dish in which it was collected under a bell jar. To transfer it from the dish to the crucible in which the zinc was to be dissolved, a platinum spoon was used.

III.—THE ARRANGEMENT OF CRUCIBLES.

Fig. 3 exhibits the arrangement of porcelain crucibles employed for the conversion of the metal into oxide. 1

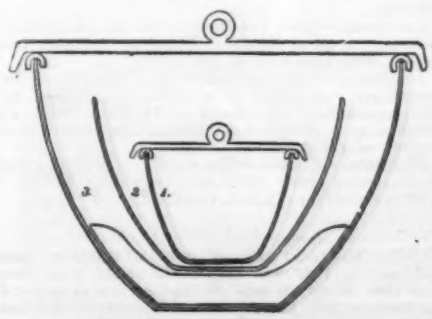


FIG. 3.

is a small crucible (No. 00) with lid, in which the zinc is treated with nitric acid, and the nitrate converted into oxide. The crucible and its lid are separated by means of hooks of platinum wire hung over the edge. This is necessary, in order that the vapors of nitric acid and of the oxides of nitrogen may freely escape, and that there may be free diffusion between the inside and the outside. As the temperature to which the oxide is heated in the muffle is very high—as high, at least, as that required for the fusion of steel, and far above that at which the glaze upon porcelain ware begins to soften—it is necessary to remove the glaze from the under side of the crucible lid; otherwise the lid would be found to be firmly stuck to the platinum hooks which separate it from the crucible. This removal is easily effected by means of hydrofluoric acid. 2 is a larger crucible (No. II) without lid, from the outside of which the glaze has also been removed to prevent sticking. 1 and 2 are weighed together, and not separated from the beginning to the end of the determination.

A piece of zinc weighing about one gramme was broken off by wrapping the larger piece in filter paper, placing it in a vise and prying with a pair of gas pipe tongs. In this way a fragment was obtained which was wholly uncontaminated by the iron of the tools used. The outside was then removed by filing and washing with absolute ether.

The pair of crucibles, 1 and 2, having been weighed, the zinc was placed in 1 and treated with an excess of nitric acid. When the metal had completely disappeared, the pair was placed in a hot air bath consisting of a large procelain and a larger iron crucible, the space between them being filled with sand. This bath was then heated, very gently at first, afterward more strongly, until the vapors of nitric acid and the oxides of nitrogen ceased to come off. From this bath 1 and 2 were transferred to crucible 3 (No. IV) (Fig. 3). The crucible 3 has in it a carefully fitted scorifier on which No. 2 rests. It is also supplied with a lid which is somewhat raised by means of hooks of platinum wire. To prevent sticking, the glaze is removed from the under side of the lid.

Finally, the whole arrangement, consisting of crucibles 1, 2, and 3, was placed in a muffle and heated for three hours to a temperature as high as that required for the fusion of steel. After weighing, the oxide was again heated as before, but in no case was there any loss in weight after the first ignition.

IV.—THE WEIGHING.

The balance used was a No. 8 long-armed one made by Becker & Sons. It was supported by iron brackets fastened to one of the foundation walls of the laboratory. The following table gives the displacements of the zero point produced by one milligramme:

Load.	No. Divisions on Scale.
Empty.	5·18
5 grammes.	5·09
10	5·08
15	5·07
20	5·07
25	5·05
30	5·03
35	5·00
40	4·89
45	4·90
50	4·85

All weighings were made late at night, after the laboratory and the streets in its vicinity had become quiet. To determine whether the balance was sufficiently at rest for weighing, a thin glass bottle partly filled with mercury was kept in the case. In this way the slightest tremor could be detected by the agitation of the surface of the mercury. The methods of weighing by vibrations and of double weighing—that is, upon both pans—were employed throughout. Each zero point was determined by means of three series of observations, one with short, another with long, and a third with medium excursions of the pointer. The weight producing a given displacement of the zero point was not calculated from the above table of sensibility. The sensibility of the balance with the load, whatever it might be, was determined at the time of weighing, and from that the weight to be ascertained was estimated. In order to assure himself that the weighings should not be vitiated by changes in the relative lengths of the arms, the operator—having some hours beforehand closed the room, shut off the register through which the room was warmed, and lighted the lamp, which was stationed above and behind his head—would determine the position of the zero point of the empty balance. After waiting an hour, without moving from his place before the balance, he would again determine the zero point. For the same purpose the zero point was always determined just before and just after each weighing. This method is believed to be much more certain than that of placing thermometers at each end of the balance case.

The weights used belonged to a set obtained from Becker Brothers. At our request they were adjusted with the utmost care by the makers, and on comparison they showed unusually good agreement

In order to avoid the necessity of reducing our weighings, and to make ourselves at the same time independent of the varying humidity of the atmosphere, the crucibles 1 and 2 were weighed by taring. Two crucibles of the same size, and as nearly as possible of the same weight, but slightly lighter, were selected and prepared in every respect like 1 and 2, to serve as a tare. The platinum hooks upon 1, and those upon the corresponding crucible of the tare, were brought to the same weight by filing. The weight of the tare was then brought to within less than a milligramme of that of the crucibles 1 and 2, by the addition of a thin piece of porcelain obtained from a crucible of the same kind. The slight difference between the weight of the crucibles and that of the tare could then be determined by the displacement of the zero point without the use of weights. The tares were treated with nitric acid and heated in the bath and muffle in every respect like the crucibles in which the determinations were made.

V.—THE RESULTS.

The method in its perfected form worked so smoothly that we were not obliged to discard a single determination. The following table contains the results of fifteen successive experiments:

---

* Jahresb. 1884, 1220. † Jahresb. 1882, 161.
‡ Archives des Sciences Phys. et Nat. (3) 10, 194.

	Wt. of Zinc.	Wt. of ZnO.	At. Wt. Zn. (O=16.)	At. Wt. Zn. (O=15.96.)
1	1.11616	1.38973	65.281	65.119
2	1.08423	1.38782	65.253	65.091
3	1.11628	1.39087	65.281	65.119
4	1.05760	1.31681	65.281	65.118
5	1.04801	1.30493	65.268	65.105
6	1.02957	1.28193	65.276	65.113
7	1.09181	1.35944	65.273	65.110
8	1.16413	1.44955	65.258	65.095
9	1.07814	1.34248	65.255	65.095
10	1.12754	1.40400	65.256	65.093
11	0 91112	1.13446	65.272	65.109
12	1.10011	1.36981	65.264	65.101
13	1.17068	1.45726	65.273	65.111
14	1.08148	1.28436	65.263	65.100
15	1.05505	1.31365	65.277	65.114
		Mean,	65.269	65.106
		Highest,	65.281	65.119
		Lowest,	65.253	65.091
		Difference,	0.028	0.028

If we calculate the atomic weight from the sums of the quantities of zinc taken and oxide obtained, as recommended by Meyer and Seubert,* we have:

Atomic Wt. of Zn. (O=16.)	Atomic Wt. of Zn. (O=15.96.)
65.2693	65.1066

We give below the two series of results obtained by Marignac† by the analysis of the double chloride of zinc and potassium (O = 16):

1st Series.		2d Series.
65.26		65.28
65.23		65.39
65.37		65.32
65.31		
65.28	Mean,	65.33
	Highest,	65.39
Mean, 65.29	Lowest,	65.28
Highest, 65.37	Difference,	0.11
Lowest, 65.22		
Difference, 0.15		

VI.—OBJECTIONS TO THE METHOD.

Marignac‡ has offered two objections to this method of determining the atomic weight of zinc which, if well founded, would render the results obtained by it wholly worthless; we have therefore taken great pains to investigate their validity.

These objections are:

1st. That the oxide of zinc dissociates at high temperatures.

2d. That the oxide of zinc, though heated to the temperature at which it begins to dissociate, still retains oxides of nitrogen.

To determine whether the oxide of zinc does dissociate at high temperatures, we divided about fifteen grammes of the oxide, prepared from our pure metal, nearly equally between two platinum crucibles which had been tared by other crucibles of the same kind. The crucibles containing the oxide, and the tares belonging to them, were then heated for three hours in a muffle furnace to a temperature sufficient to fuse completely a ten gramme piece of steel file which was placed upon a scorifier beside them. The difference between the weights of the crucibles plus the oxide and those of their tares was then determined. Afterward the crucibles and tares were five times reheated the same length of time and as nearly as possible to the same temperature; in every case the piece of steel file placed in the muffle was fused. We give the results in tabular form.

SERIES I.

	Apparent Gain.	Apparent Loss.
After 1st ignition,	0.00004 gram.	..
After 2d,	0.00002	..
After 3d,	..	0.00005 gram.
After 4th,	0.00004	..
After 5th,	..	0.00004
Total gain,	0.0001 Total loss,	0.00009

SERIES II.

	Apparent Gain.	Apparent Loss.
After 1st ignition,	0.00006 gram.	..
After 2d,	..	0.00005 gram.
After 3d,	..	0.00001
After 4th,	0.00004	..
After 5th,	..	0.00001
Total gain,	0.0001 Total loss,	0.00007

It appears from these results that the oxide of zinc does not dissociate at the fusing point of steel. The interior of the platinum crucibles in which the oxide was heated did not exhibit a trace of the tarnish observed by Erdmann.§ The apparant gain in weight of one one-hundredth of one milligramme in one case, and the apparent loss of three one-hundredths of a milligramme in the other, have, of course, no significance whatever.

It remained for us to find the cause of the tarnish observed by Erdmann, and of the undoubted loss of weight observed by Marignac,‖ when the oxide of zinc is heated in a platinum crucible over a flame. This we have done. In a former article¶ we have shown that the atmosphere within any platinum vessel heated by a flame receives free hydrogen, and that the phenomenon referred to is, in all probability, one of reduction, and not of dissociation, as Marignac supposed. In that article we suggested that perhaps the platinum itself may be a cause of the dissociation of water in the flame, but more recent experiments have convinced us that this decomposition is quite independent of the presence of the platinum.

To test for the presence of the oxides of nitrogen, Marignac** dissolved the oxide of zinc in hydrochloric acid in the presence of starch and iodide of potassium. A slight blue coloration was observed. In order that this test may be relied upon, certain conditions must be fulfilled.

1st. The hydrochloric acid must be free from chlorine or any other oxidizing agents.

2d. The iodide must be free from the iodate of potassium.

3d. All of the solutions must be free from absorbed oxygen.

4th. The solutions must be protected from the air.

Whether Marignac observed all of these precautions, does not appear from his paper. Apparently he must have neglected some one or more of them, since we were not able, with any specimen of our oxide, to obtain the slightest trace of a blue coloration by this method.

To remove any chlorine contained in our hydrochloric acid, we agitated the diluted acid with metallic mercury. To remove the iodate from the iodide of potassium, we boiled the solution with zinc amalgam.

To remove absorbed oxygen, all of our solutions were thoroughly boiled. The order in which the materials were brought together is as follows: The boiling solution of iodide was poured into the boiling starch paste in an Erlenmeyer flask. To this mixture was added first the zinc oxide and then the boiling hydrochloric acid. The steam rising from the liquid sufficed to protect it from the air.

* Die Atomgewichte der Elemente, p. 13.
† Archives des Sciences Phys. et Nat. (3) 10, 204.
‡ Ibid. 10, 194.
§ Pogg. Ann. 62, 612.
‖ Archives des Sciences Phys. et Nat. (3) 10, 195.
¶ This Journal, 10, 148.
** Archives des Sciences Phys. et Nat. (3) 10, 195.

MINERAL RESOURCES OF THE UNITED STATES—CALENDAR YEAR 1887.

FOR the following summary we are indebted to David T. Day, Chief of Division of Mining Statistics and Technology, United States Geological Survey, for advanced proofs from the volume "Mineral Resources of the United States," now in press.

METALS.

Iron.—The principal statistics for 1887 were: Domestic iron ore consumed, about 11,300,000 long tons; value at mines, $33,900,000. This is an increase over 1886 of 1,300,000 tons in quantity and $5,900,000 in value. Imported iron ore consumed, 1,194,301 long tons; total iron ore consumed in 1887, about 12,494,301 long tons; or 1,454,868 tons more than in 1886. Pig iron made, 6,417,148 long tons; value at furnace, $121,925,800. This is an increase over 1886 of 733,819 tons in quantity and $26,730,040 in value. Steel of all kinds produced, 3,339,071 long tons, an increase of 776,569 tons over 1886; value at works, $103,811,000. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $171,103,000, an increase of $28,603,000 as compared with 1880. Limestone, used as flux in the manufacture of pig iron in 1887, about 5,377,000 long tons; value at quarry, about $3,226,200.

Gold and Silver.—The total value of gold produced in 1887 was $33,100,000, a decrease of $1,900,000 from 1886. Silver increased from $51,000,000 in 1886 to $53,441,300 (coining value) in 1887.

Copper.—Total production 184,670,524 pounds, of which 3,750,000 pounds were made from imported pyrites. The total value was $21,052,440, at an average of 11·4 cents per pound. The estimated total consumption of copper in the United States increased by about 14 per cent.

Lead.—The production of lead was 160,700 short tons, valued at $14,463,000 at $90 per short ton. The heavy increase of "desilverized" lead from 114,829 short tons in 1886 to 135,552 in 1887 was probably due to the importation of Mexican lead silver ores. The large product of non-argentiferous lead, 25,148 short tons, is due chiefly to the development of the Saint Joe district in Missouri. The production of white lead, and the several oxides, from pig lead increased to a total of about 75,000 short tons.

Zinc.—The producers' returns show an increase from 42,641 short tons in 1886 to 50,340 in 1887. The price increased to 4¾ cents per pound, making the total value in 1887, $4,782,300. The production of zinc oxide was practically steady at 18,000 short tons, valued at $1,440,000.

Quicksilver.—Production and value increased from 29,981 flasks, valued at $1,060,000, to 33,825 flasks, valued $1,429,000. Except 65 flasks from Oregon, the total supply came from California. The price in 1887 varied from $36.50 to $48 per flask in San Francisco.

Nickel.—The supply includes 188,125 pounds of metallic nickel, valued at $117,200; 10,846 pounds of metallic nickel contained in matte, and 11,595 pounds contained in nickel ammonium sulphate. Total value, $133,200.

Cobalt Oxide.—The product includes 5,769 pounds of cobalt oxide for potters' use and 12,571 pounds of oxide in matte exported to Europe. Total value, $18,774.

Chromium.—Shipments from California increased to 3,000 long tons on account of better freight facilities by rail to the Eastern States. The total value in San Francisco was $40,000.

Manganese.—The total production in manganese ore in the year ending December 31, 1887, was 34,524 long tons, valued at $333,844. The production of manganiferous iron ore was 211,751 tons, valued at about $600,000. The production of argentiferous manganese ores was 60,000 tons, valued, chiefly for its silver, at about $600,000.

Antimony.—The production, all in California, was 75 tons, valued at $15,500. This is an increase from 35 tons in 1886, valued at $7,000.

Aluminum.—The production of aluminum bronze containing 10 per cent. of aluminum increased to 144,764 pounds in 1887, valued at $57,905. Other alloys, principally of iron and aluminum, amounted to 42,617 pounds, worth $17,000.

Platinum.—Considerable search by dealers produced 448 ounces of crude platinum, valued at $1,838. Part of this came from British Columbia.

FUELS.

Coal.—The total production of all kinds of commercial coal in 1887 was 123,965,255 short tons (increase over 1886, 16,283,046 tons), valued at the mines at $173,530,996 (increase, $26,418,241). This may be divided into Pennsylvania anthracite 39,506,255 short tons (increase, 2,809,780 short tons), or 35,273,442 long tons (increase, 2,508,732 long tons), valued at $79,365,244 (increase, $7,807,118); all other coals, including bituminous, brown coal, lignite, small lots of anthracite produced in Colorado and Arkansas, and 6,000 tons of graphitic coal mined in Rhode Island, amounting in the aggregate to 84,459,000 short tons (increase, 13,473,269 tons), valued at $94,165,752 (increase, $18,611,123).

The colliery consumption at the individual mines varies from nothing to 8 per cent. of the total output of the mines, being greatest at special Pennsylvania anthracite mines and lowest at those bituminous mines where the coal bed lies nearly horizontal and where no steam power or ventilating furnaces are used. The averages for the different States vary from 2·1 to 6 per cent., the minimum average being in the Pennsylvania bituminous and the maximum average being in the Pennsylvania anthracite region.

The total output of the mines, including colliery consumption, was: Pennsylvania anthracite, 37,573,247 long tons (increase over 1886, 2,725,670 long tons), or 42,088,197 short tons (increase, 3,052,751 short tons); all other coals, 87,837,360 short tons (increase, 14,120,403 tons); making the total output of all coals from mines in the United States, exclusive of slack coal thrown on the dumps, 129,925,557 short tons (increase, 17,182,154 tons), valued as follows: Anthracite, $84,552,181 (increase, $8,433,061); bituminous, $97,939,056 (increase, $19,458,600); total value, $182,491,837 (increase, $27,891,661). The above figures show a notable increase in 1887 over 1886 in the aggregate output and value of both anthracite and bituminous coal.

Coke.—The total production of coke in the United States for the year ending December 31, 1887, was 7,857,487 short tons, valued at $15,723,574. This is the greatest product ever reached in the United States, being 1,022,419 tons greater than in 1886.

Petroleum.—Total production, 28,249,543 barrels of 42 gallons each. The total value, at an average of 80 cents, was $16,949,726. The increase over 1886 was very slight, only 139,428 barrels. There was a decrease of 11¼ cents per barrel in the average price.

Natural Gas.—The production of natural gas in the United States in 1887 was equivalent to 9,055,000 short tons of coal displaced. This, at an average value of $1.50 a ton, would make the value of the coal displaced by natural gas (which is the measure of the value of the gas) $13,582,500. In 1886 the corresponding quantity was 6,353,000 tons, worth $9,847,150.

STRUCTURAL MATERIALS.

Building Stone.—Direct returns from producers show a total value of $25,000,000. This marked increase shows that the statement for 1886 was too small.

Brick and Tile.—Value, $40,000,000. This represents an increase of about 13 per cent. in the production of brick and a decrease in tile, owing to the drought in 1887 in Indiana and Ohio. Prices were slightly lower.

Lime.—The production is estimated at 46,750,000 barrels, with an average value of 50 cents per barrel.

Cement.—The production of cement from natural rock was 86,692,744 barrels, valued at 77½ cents per barrel, making $5,186,877 as the value of the year's product.

ABRASIVE MATERIALS.

Buhr Stones.—The value of the total product is estimated at $200,000.

Grindstones.—In Ohio and Michigan 37,400 tons were produced, valued at $224,400.

Corundum.—Total production from North Carolina and Georgia 600 short tons, with a spot value of $108,000.

Novaculite.—Production 1,200,000 pounds, valued in the rough state at $16,000.

Infusorial Earth.—Maryland produced 3,000 short tons, worth $15,000. A small quantity was produced in Nevada and in New Mexico.

MISCELLANEOUS.

Precious Stones.—The value of American gems in the rough state amounted to $88,600, besides gold quartz for specimens and gems, valued at $75,000.

Phosphate Rock.—South Carolina phosphate rock, 480,558 long tons, valued at $1,836,818; an increase of 50,009 tons, but a decrease of $36,118 in value, due to greater competition, reducing the price to $3.75 per ton for land and $4 for river rock.

Marls.—In New Jersey the production is estimated at 600,000 tons, worth about $900,000. While the New Jersey marl is yielding slowly to commercial fertilizers, the Virginia marls, as well as those in North and South Carolina, Georgia, Mississippi, and Florida, are finding increased local use.

Salt.—Production in 1887, 7,831,962 barrels (of 280 pounds), value $4,093,846. The annual production has increased each year since 1883, but the total value has declined, being less in 1887 than in 1884, although only 6,514,937 barrels were made in that year.

Bromine.—Stocks accumulated in 1886 and reduced the output of 1887 to 199,087 pounds, valued at $61,717. The price was held at 31 cents per pound.

Borax.—Production, 11,000,000 pounds, all from California and Nevada. Total value, $550,000, at 5 cents per pound for the average grade. The price was rising at the close of 1887.

Sulphur.—Production about 3,000 tons from Utah, worth $100,000. Litigation checked the use of an increased plant. The imports of Sicilian sulphur, with small shipments from Japan, were 96,882 long tons, valued at $1,688,360.

Pyrites.—Production 53,500 long tons, valued at $210,000, at $4 per ton at the mines.

Barytes.—The production increased to 15,000 long tons of crude barytes, valued at $75,000 at the mines.

Gypsum.—The condition of the industry is practically unchanged. The estimated total product was 95,000 short tons of crude gypsum, valued at $425,000. In addition, 162,154 long tons of crude gypsum were imported, chiefly from Nova Scotia.

Mica.—The production increased to 70,500 pounds, valued at $142,250. The increase was chiefly in North Carolina. New Hampshire, Massachusetts, and Virginia also produced mica. No shipments were reported from the Black Hills or New Mexico. The use of mica waste is increasing; 2,000 tons, worth $15,000, were ground in 1887.

Feldspar.—The amount consumed, principally by potters, was 10,200 long tons, valued at $56,100 before grinding. This includes freight to the principal markets, Trenton or New York. The consumption in 1886 was about 5,000 tons less than the production returned by quarrymen.

Flint.—For pottery 19,800 tons were used. Including the use for sandpaper and in glass manufacture, the

total consumption was about 32,000 tons, worth, unground, $185,000.

Potters' Clay.—The consumption of kaolin and ball clay by potters aggregated 28,000 tons, valued at $290,000. In addition, the potters used 15,000 tons of fire clay, worth $50,000.

Asbestos.—The total product hardly exceeded 150 tons, worth $4,500. In addition, several hundred tons of fibrous actinolite were used for weighting paper.

Mineral Paints.—Including ocher, metallic paints, and small quantities of umber and sienna, the production amounted to 20,000 long tons, selling for $310,000 at the mines.

Graphite.—The production at Ticonderoga is reported as unchanged. Small lots ranging from graphitic clay to pure graphite were produced in North Carolina. Total production, 416,000 pounds, worth $34,000. This does not include 500 tons of impure graphite mined in Rhode Island for foundry facings.

Fluorspar.—The production remained constant at 5,000 tons in Indiana. The total value was $20,000.

Mineral Waters.—The product which was sold amounted to 8,259,600 gallons, worth $1,261,473.

Totals.—The following tabular statement shows an aggregate value of $538,056,345 for the year. This is the largest total ever reached by the mineral industries of any country. It is nearly $73,000,000 more than the product of the United States in 1886, and considerably more than $100,000,000 in excess of the year 1885. Of many items which have contributed to this result, it will be noted that all the metals increased in quantity, except gold and the minor metal, nickel, and nearly all increased in price. The significance of this is seen in the increase in production of the fuels necessary for reducing these metals and preparing them for use. All of these fuels, including natural gas, show a marked increase. The increased value of building stone is principally due to a more careful canvass of this industry than has been possible in previous years. It is not probable that the great total recorded for 1887 will be equaled in the present year, 1888.

Metallic Products of the United States in 1887.

	Quantity.	Value.
Pig iron, spot value.....long tons..	6,417,148	$121,925,800
Silver, coining value.....troy ounces..	41,289,240	53,441,300
Gold, coining value..... "	1,596,500	33,100,000
Copper, value at New York City...pounds..	184,670,524	21,052,440
Lead, value at New York City...short tons..	160,700	14,463,000
Zinc, value at New York City. "	50,340	4,782,300
Quicksilver, value at San Francisco.....flasks..	33,825	1,429,000
Nickel, value at Philadelphia.....pounds..	205,556	133,200
Aluminum contained in alloys.....	.....	74,905
Antimony, value at San Francisco.....short tons..	75	15,500
Platinum, value (crude) at New York City.....troy ounces..	448	1,838
Total.....	.....	$250,419,283

Non-Metallic Mineral Products of the United States in 1887 (*spot values*).

	Quantity.	Value.
Bituminous coal.....long tons..	78,436,214	$97,999,656
Pennsylvania anthracite..... "	37,578,747	64,552,181
Building stone.....	.....	25,000,000
Lime.....barrels..	46,750,000	32,375,000
Petroleum..... "	28,249,543	16,949,726
Natural gas.....	.....	13,582,500
Cement.....barrels..	6,092,744	5,186,877
Salt..... "	7,831,962	4,093,846
Limestone for iron flux.....long tons..	5,377,000	3,226,200
South Carolina phosphate rock.. "	480,558	1,836,818
Zinc white.....short tons..	18,000	1,440,000
Mineral waters.....gallons sold..	8,259,609	1,261,473
Borax.....pounds	11,000,000	550,000
Gypsum.....short tons..	95,000	425,000
Manganese ore.....long tons..	34,524	333,844
Mineral paints..... "	20,000	310,000
New Jersey marls.....short tons..	600,000	300,000
Pyrites..... "	52,500	210,000
Flint..... "	32,000	185,000
Mica.....pounds..	70,500	142,250
Corundum.....short tons..	600	108,000
Sulphur..... "	3,000	100,000
Precious stones.....	.....	88,000
Crude barytes.....long tons..	15,000	75,000
Gold quartz, souvenirs, jewelry, etc.....	.....	75,000
Bromine.....pounds..	199,087	61,717
Feldspar.....long tons..	10,200	56,100
Chrome iron ore..... "	3,000	40,000
Graphite.....pounds..	416,000	34,000
Fluorspar.....short tons..	5,000	20,000
Slate, ground as pigment.....long tons..	2,000	20,000
Cobalt oxide.....pounds..	18,340	18,774
Novaculite..... "	1,200,000	16,000
Asphaltum.....short tons..	4,000	16,000
Asbestos..... "	150	4,500
Bauite.....pounds..	1,000	3,000
Total.....	.....	$281,687,062

Résumé of the Values of the Metallic and Non Metallic Mineral Substances Produced in the United States in 1887.

Metals.....	$250,419,288
Mineral substances named in the foregoing table..	281,687,062
	$532,056,345
Estimated value of mineral products unspecified.....	6,000,000
Grand total.....	$538,056,345

[Continued from SUPPLEMENT, No. 659, page 10531.]

GEOLOGY.

By ARCHIBALD GEIKIE, LL.D., F.R.S.

IGNEOUS ROCKS.

I. What Igneous Rocks Are.

TURNING back to one of the early lessons of this book, you find that we divided stones into three great classes, of which the third was named the igneous class. This word igneous means literally fiery. It does not very accurately describe the rocks to which it is applied, but it has long been in use to include all rocks which have been actually melted within the earth, or which have been thrown out at the surface by the action of volcanoes. So that the igneous rocks owe their origin to some of the effects of the internal heat of the earth, about which you have already learned something and must now learn more.

The first thing to occur to you when you begin to search for examples of igneous rocks will probably be the fact that they are by no means so abundant as the other two great classes of rocks. Take Great Britain as an illustration. If you traversed the country from end to end, you would meet everywhere with rocks belonging to the sedimentary and the organic series. But you would travel over considerable spaces without meeting with any of the igneous class. The whole of that part of England, for example, which lies to the southeast of a line drawn from Lyme Regis, by Leicester, to Flamborough Head, contains not a single mass of igneous rock. And yet were you to cross over into North Wales, or Cumberland, or the midland valley of Scotland, you would find rocks of that kind in abundance, protruding through the surface, and forming many of the highest and most picturesque hills and crags in these parts of the island. So that though igneous rocks are not universally diffused, they occur abundantly enough in many places. Even in so small a space as Britain they are plentiful; they are likewise to be met with in most parts of the world. They have a very curious and important history, and hence it is desirable that you should know what they really are, and how you could recognize them.

You will find that the solid materials cast up by volcanoes are of two kinds—1st, streams of molten rock called lava poured down the sides of a volcanic mountain during an eruption; and 2d, immense quantities of dust, sand, and stones, cast up into the air from the mouth of the volcano, and falling down upon the mountain, sometimes even all over the surrounding country for a distance of many miles.

Here then are two very dissimilar kinds of rock material discharged from the interior of the globe. The lava cools and hardens into a solid rock. The loose ashes and stones, likewise, are in time pressed and hardened into more or less firm beds of stone. So that two totally distinct kinds of rock are laid down upon the surface of the earth by the volcano. In the case of the lava, the rock, if you look at it with a magnifying glass, is seen to be made up of distinct crystals all matted together. The beds of ashes, on the other hand, no matter how compact they may have become, are found to be made up of irregular fragments of various kinds of stone, and of all sizes, from the finest dust up to big blocks. By attending to this very simple and intelligible difference you could arrange igneous rocks into two great groups—1st, the crystalline, that is, those which are made up of crystals, and which have once been in a melted state; and 2d, the fragmental, that is, those which consist of the loose materials thrown out during volcanic explosions.

1. *Crystalline Igneous Rocks.*—The piece of granite which we have examined is an example of one form of the rocks of this class. We have seen how greatly it differs from such rocks as sandstone or chalk. But there are many other varieties of crystalline igneous rock. In Fig. 25, for example, one of these varieties is

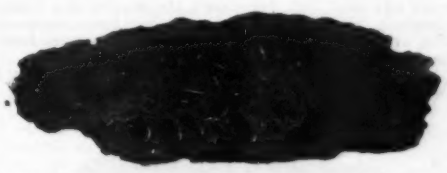


FIG. 25.—Piece of Lava, showing the crystals and the steam holes.

drawn. It is a fragment broken from a current of lava which in a molten state ran down the side of a volcano. You observe the little angular crystals, some of them black and large, others mere white specks in the general mass of the stone. But besides the crystals you notice a number of rounded holes or cavities, as if little water-worn pebbles had fallen out of the rock. When the rock was still melted it was full of imprisoned steam and gas which were constantly striving to escape to the surface. It was this steam which collected into little bubbles and formed the curious set of holes in the mass of the still molten rock. In the same way the holes which you often see in the heart of a loaf of bread were formed by the struggles of the steam to escape from the dough as it was heated in the oven.

All lava belongs to this class of rocks. One or two pictures may serve to show you some of the more simple and striking features of these lava masses. In Fig. 26 a drawing is given of part of the Island of Volcano, in the Mediterranean, in which you will see how the lava has risen up the inside or throat of the volcanic hill to the edge of the crater and run down the outside of the slope. When that took place the lava was of course thoroughly molten, like liquid iron,

FIG. 26.—View of the north side of the volcanic cone of the Island of Volcano, showing a stream of black lava which has not flowed down to the bottom of the slope.

and hardened as it cooled in moving. You observe that it has not been able to reach the bottom of the hill. It was in truth a very small stream, cooling and hardening before it got even down to the foot of the slope. But look now at Fig. 27. You there perceive that a much more copious stream of lava has issued, that one side of the volcanic cone has been broken

FIG. 27.—View of lava stream issuing from one of the extinct volcanic cones of Auvergne, in Central France. (Scrope.)

down so as actually to let you see into the crater, and that the lava has burst out, and poured down the sloping ground. Thus, each outburst of lava is the escape of a river of molten rock from the top or the side of a volcano. Like an ordinary river of water, it of course sweeps into the readiest hollow or valley it can reach, so that round an active volcano the valleys often get quite filled up and buried under the vast sheets of lava which are poured out. Like rivers, too, the streams of lava vary greatly in size. In Fig. 26 you see one which was too feeble to reach the base of the hill, but in the famous eruption of Skaptar Jokul, Iceland, in the year 1783, two enormous streams were poured out, one of them flowing to a distance of forty-five and the other of forty miles. They ranged from less than seven to twelve or fifteen miles in breadth, with a thickness of a hundred, and sometimes in confined valleys even six hundred feet.

If you paid a visit to any ordinary stream of lava after it had come to rest and cooled, you would find its surface to be an irregular accumulation of rough black or dark brown fragments very like the "slags" or "clinkers" from a furnace. Down below this rough surface the rock is more compact, usually dark in color, containing various crystals scattered through its mass, and often full of holes, as shown in Fig. 25. In some cases the lava as it grew solid has assumed a curious and beautiful internal arrangement into columns. The pillars of Fingal's Cave, in Staffa, and of the Giant's

FIG. 28.—View of the Island of Staffa, with Fingal's Cave.

Causeway, in Antrim, have been produced in this way. At both of these places the rock was once a molten lava. As it grew cold and solid it contracted, and in so doing became divided into these regular columns. You might imitate this arrangement by putting starch in warm water, stirring it well round, and then letting it stand. By degrees you would observe that as the starch grows solid it assumes an internal columnar arrangement, not unlike the basalt.

Next let us see where rocks of this kind are to be met with. Of course you would expect to find them round the flanks of an active volcano. And indeed at most volcanoes, as Vesuvius or Etna, or those of Iceland, they abound. But you would trace them too round volcanoes no longer in activity, as, for example, in that part of Central France where the extinct volcanoes occur, of which one is drawn in Fig. 27. And as you traveled over the world, you would recognize them in hundreds of places where no volcanic eruption has ever been known since human history began. In fact, they would be the witnesses to you of where old volcanoes had once been at work. In this way, by learning how to detect these forms of ancient lava, you would be able to prove that there had been volcanoes in very far distant times in districts where there are now busy cities or fertile fields.

For example, though no active volcanoes exist in Great Britain at the present day, they can be shown to have often broken out here in olden times, long before man appeared upon the earth. Some of the oldest traces of volcanic action are to be met with in North Wales, where not a few of the lava beds form prominent features in the scenery of that rugged district. Much younger are the sheets of various ancient lavas which stretch across the middle of Scotland, and there compose most of the hills. But the latest of the British volcanoes were those which ranged in a long line from Antrim in Ireland, through the Western Islands, and away north by the Faroe Islands into Iceland. The vast terraced mountains of Antrim, Mull, Skye, and Faroe have been built up of piles of lava sheets.

But there are other crystalline igneous rocks besides those which come to the surface and flow out there as molten lava. Granite, for example, which we have

already examined, is an admirable illustration of the crystalline character. But instead of coming to the surface to cool there, granite appears to have crystallized and cooled deep down beneath great masses of other rocks. Yet it now forms bare, naked, lofty mountains. Many of the Scottish Highland hills, for example, as Ben Nevis, Ben Maedui, and Cairn Gorm, consist of granite. It rises high, too, in the center of the chain of the Alps. Granite often sends out veins into the rocks which lie above and around it. It could not have done this unless it had been in a fluid or pasty state.

But you may ask, if granite has not crystallized at the surface, but under masses of other rocks, how does it come to be at the surface now, and not there only, but even forming the crests of bare, lofty mountains? This question is not quite so easy to dispose of, but you will probably be able to see how it is to be answered after you have come to that portion of these lessons which treats of what is called the crust of the earth.

2. *Fragmental Igneous Rocks.*—The piece of stone represented in Fig. 29 is a fragment from a bed of consolidated volcanic ashes. You notice that it is made up of irregular and angular fragments. These are little bits of lava and other rocks which have been blown into the air by the discharges of the volcano. You observe too that when they fell to the ground and accumulated above each other there they took a stratified form. That layer of coarse fragments at the bottom points to a shower of coarser volcanic ashes, while the layers of smaller fragments above show how showers of finer dust afterward fell through the air. Now this is the kind of material under which the old Roman city of Pompeii was buried. It fell upon the streets and houses and gradually covered them up as the eruption of the neighboring volcano continued. And at this day, when they excavate the ruins, the workmen find the streets and chambers all choked up with layers of coarser and finer volcanic ash and dust arranged just as you see in Fig. 29.

FIG. 29.—Piece of Volcanic Tuff—a rock formed of consolidated volcanic ashes.

Of course, if the volcanic ashes fell over the sea or a lake, they would settle down beneath the water and form deposits there. They might cover up and preserve, too, the remains of any plants or animals which might be lying on the bottom at the time of the eruption. This has often happened in past times. In the mountain of Snowdon in Wales, for example, many hundreds of feet of such consolidated volcanic dust still exist, and on examining this material you may still pick out shells and other marine organisms which show that the volcanic materials fell into the sea. Again, in Scotland many beds of similar nature are found lying among seams of coal. These masses of consolidated volcanic dust and stones are known by the name of tuff.

II. Where Igneous Rocks Come From.

If I ask you from what source the igneous rocks have been derived, you will reply that they have come up from the intensely hot regions within the earth. In the Physical Geography Primer some account is given of the inside of the earth and of the proofs that it has a high temperature. I need not remind you what a very little part of the outer portion of our planet we can actually see, even from the top of the highest mountain to the bottom of the deepest mine. Let us go over in this lesson a little more in detail the evidence for the great heat of the earth's interior, and the connection between that heat and certain movements and changes at the surface.

Deep Borings and Mines.—If you were taken down to the bottom of a deep mine in England, you would find the temperature much warmer there than near the

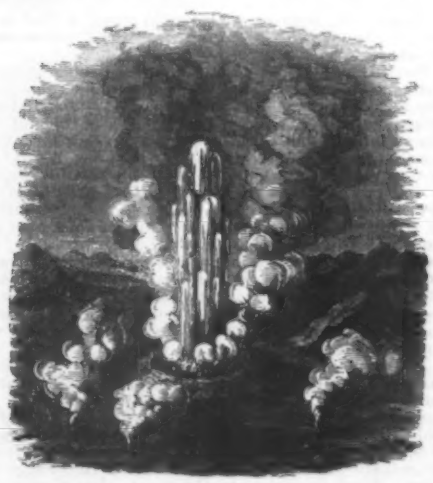


FIG. 30.—View of Hot Springs, or Geysers, Iceland.

surface, and a similar increase of heat would meet you in the deep mines of every country in the world. You would soon discover, too, that, on the whole, the deeper the mine the greater the warmth would be. In the same way, were you to bore a deep narrow hole into the earth for several hundreds of feet and let a thermometer down to the bottom, you would find that the mercury would rise in the tube.

Experiments of this kind have been made all over the globe, with the result of showing that after we get down for a short and variable distance below the surface, we reach a temperature which remains the same all the year, and that underneath that limit the temperature rises about 1° Fahrenheit for every fifty or sixty feet of descent. If this rate of increase continues we should get uncomfortably hot before having descended very far. For instance, at a depth of about two miles water would be at its boiling point, and at depths of twenty-five or thirty miles, the metals would have the same temperatures as those at which they respectively melt on the surface of the earth. It is clear from this kind of evidence that the inside of our planet must be in an intensely heated condition.

Proofs of another kind lead to the same conclusion. The city of Bath has long been famous for its wells. Now, these come out of the earth at a temperature of 120° Fahr., that is, rather hotter than the water is usually made in a hot bath. And this warm water has been rising to the surface and flowing to the sea

FIG. 31.—Vesuvius, as it appeared at the beginning of the Christian era, when it was a *dormant* volcano.

ever since the Romans were in this country, and probably long before that. In many other parts of the world similar hot springs occur. Iceland, for example, furnishes some remarkable examples called geysers, where at intervals the boiling water and steam rush out with a great noise, and rise high into the air (Fig. 30). To keep up such hot springs in every quarter of the globe there must assuredly be great stores of heat within the earth.

Neither the heat of deep mines nor of hot springs affords such an impressive lesson as to the earth's internal high temperature as is furnished by volcanoes. The hot vapors and steam which rise from the craters of volcanoes, the torrents of hot water which sometimes issue from their sides, the streams of molten lava which break out and roll far down the slopes of a volcanic mountain, burning up and burying trees, fields, gardens, and villages—are all tokens of the intense heat of the inside of the earth from which they come.

At the present time there are, it is said, about 270 volcanoes either constantly or at intervals throwing out

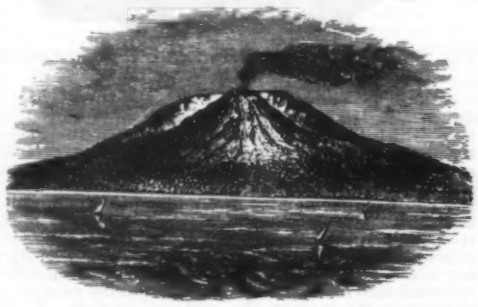


FIG. 32.—Vesuvius as it appears at the present time—an *active* volcano.

steam, hot ashes, and lava, in different parts of the globe. You will comprehend how widely they are distributed if you again take a map of the world and note upon it the lines of active volcanoes. First of all, down the whole line of the mountains which range along the western margin of the American continent, volcanoes are numerous, some of them of vast height like Cotopaxi (18,877 feet). From the northern extremity of America they extend, by way of the Aleutian Islands and Japan, to the Malay Archipelago, where in Java they greatly abound. From that point they may be traced at wide intervals into New Zealand on the one hand, and on the other through the center of Asia by way of the Red Sea and the Mediterranean, up to Iceland and down to the Azores, and thence across to the West Indies and the center of America. Even among the perpetual snows of the south polar regions they have been met with, and also far within the Arctic circle at the Island of Jan Mayen.

But besides these volcanos which are still active, many others occur from which no eruptions have ever been seen to take place, and which are therefore called dormant or extinct (see Figs. 27 and 31). If you were to put down upon a map the position of every volcano which either now or at some past time has given out hot gases, steam, ashes, or lava, you would probably find very few large areas of the earth's surface in which no trace of volcanic action can be found. Britain, for instance, is now wholly free from any volcanic disturbance, and yet, as already pointed out, you would need to mark many places on the map of this country as having once been the scene of long continued volcanic eruptions. You would have to put some dots upon the map round Exeter to mark the position of some ancient volcanoes; a good many in Wales, some in Derbyshire, and others in Cumberland. You would have to cover almost all the center of Scotland with such dots, for that region is full of volcanic rocks, and in Ireland too there would be a good many scattered marks.

In this way you would come to see how universal volcanic action has been, on the whole, over the globe, and therefore how powerfully and generally the heat of the interior has manifested itself at the surface.

But in igneous rocks you do not see the only evidence of how the internal heat affects the surface of the earth. There can be little doubt that earthquakes must be mainly due to commotions which take their origin from the effects of this heat.

Perhaps you will ask, why, since the inside of the planet is so hot, does it not melt the outside, or at least why is the outside not warmer? There can be no doubt that, at one time, many millions of years ago, the globe was immensely hotter than it is now. In fact, it then resembled our burning sun, of which it once probably formed a part, and from which it and the other planets were one by one detached. During the vast interval which has passed away since then it has been gradually cooling, and thus the heat in the inside is only the remains of that fierce heat which once marked the whole planet. The outer parts have cooled and become solid, but they are bad conductors of heat, and allow the heat from the inside to pass away into space only with extreme slowness. Hence, in spite of the high temperature of the interior, we are not sensible that it warms the outer surface of the earth.

To illustrate this point, suppose that you could see a volcano in the very act of pouring a great stream of molten lava down its slopes. At first the torrent would be at a white heat, glowing so fiercely that you could hardly keep your eyes upon it. But a few yards below the point from which it emerged it would begin to assume a reddish hue, which would get duller and darker, just as a live coal does when it falls from the grate upon the hearth, and the surface of the lava would at the same time get cool and solid so quickly that in a few days you might stand upon it, even though it was still red hot only a foot or two below. You might come back to it a dozen of years afterward. Its surface would be perfectly cold—a mere rough sea of black bristling lumps of rock—and yet down in the depths of the mass the rock would be still hot, and you might even meet with cracks from which the heat escapes along with wreaths of steam, and where therefore you could not hold your hand without having it burnt. Now, if a mere river of lava takes so long to cool down to its center, you can realize perhaps why it is that the huge mass of our globe should still be intensely hot inside, even though its outer portions have been solid and cool for long ages.

You are already familiar with the fact that bodies expand when they are heated, and contract as they cool. When the earth was vastly hotter than now it must also have filled more space. While cooling it has been contracting. As it is still cooling it must be still contracting, but so slowly that on the whole we are not sensible of the process. But some of the effects are visible enough among the rocks. The contraction could not fail to cause an enormous pressure or strain on the outer parts, which, since they are made of such very various materials—sedimetary, organic, and igneous rocks—would yield to the stress more in some places than in others. And thus somewhat like the skin of a dried and shriveled apple, the surface of the globe would be ridged up in one region, or would sink down in another, besides being squeezed and broken. What evidence we have for all this will be told in the next lessons.

(*To be continued.*)

THE CALIFORNIAN MUMMIES.

By WINSLOW ANDERSON, M.D.

WE have received a copy of *Bulletin* No. 1 of the California State Mining Bureau, containing a description by Winslow Anderson, M.D., of the four naturally mummified human bodies exhumed in the Sierra Madre Mountains, and now in the possession of the bureau. Excellent photographs of the mummies are given in the *Bulletin*. We make extracts as follows:

Through the liberality and untiring energy of Mr. J. Z. Davis, president of the board of trustees of the State Mining Bureau, a valuable collection of desiccated human remains has been added to the archæological department of this institution.

While the Mexican archæologist, Signor S. Marghieri, was exploring the eastern side of the Sierra Madre Mountains in Mexico, about two hundred miles south of Deming, between Coralitos and Casas Grandes, and at an elevation of nearly seven thousand feet, a hermetically sealed cave was discovered and explored. The floor was nearly smooth, the sides rough and rugged, and the vault covered with stalactites. The cave was of considerable dimensions, and proved to be a veritable sepulcher, for at the far end of this cavern four mummified human remains were found. The caves which this people sanctified by the inhumation of their dead are generally situated in the cliffs, on the banks of some large river, or high up some precipitous and almost inacessible mountain.

The bodies were found in a sitting posture, hands crossed on the breast and knees approaching the chin, with the head inclined forward. They were all carefully shrouded in their burial garments, and accurately placed facing the rising sun—the source of all light—presumably ready to rise at a moment's warning, shake the dust from their heads, and walk out of their sarcophagus. The male and the female, probably husband and wife, were seated side by side, the elder child, a boy, was placed to the right of the father, and the younger child, a little girl, to the left of the mother. In addition to the burial shrouds, the little girl was enveloped in the skin of an animal, similar to the method used on the islands of Fuerteventura, the better to preserve its tender frame.

The floor of the cavern, and the remains, were covered with a fine, impalpable dust, probably the accumulation of ages. No footprints of man or beast had desecrated the sepulcher since the time of the interment. Only one sign remained to indicate the advent of man to these now barren and desolate regions (besides the ruins of cities and casas to be noticed elsewhere), and that was the sealing of the opening of the cave. This had been accomplished by means of sun-dried adobe bricks and adobe paste, or plaster, together with natural rocks from the mountain. So carefully are these caves sealed that none but an acute observer would notice its artificial closure.

Professor Marghieri and party having determined to convey the bodies to San Francisco, the utmost secrecy was necessary, for it would have been all their lives were worth to have the Indians discover the contents

of their parcels. The aborigines of this and many other localities entertain the greatest superstitious veneration for their departed ancestors, amounting, in many cases, to actual worship, believing the spirits of the dead, of whom they cherish fabulous accounts, hover over them and their dead bodies, and protect the community from evil. Should the bodies be removed, the spirits would also follow, and the Indians would lose their guardians, and spiritual advisers. Indeed, some tribes believe that the spirit resides in the bones of the dead. Hence, while the Indians did not know specifically the place of interment of the mummified bodies, their legends teach them that the mountains and caves are peopled with the spirits of some great nation of whom they are pleased to call themselves descendants.

Accordingly, the bodies were carefully wrapped in such cloth as they had, and packed in sacks and strapped on the backs of the pack mules, and conveyed some two hundred miles to the nearest railroad station, where they were carefully repacked in suitable cases, and transported to San Francisco.

Having ascertained their whereabouts, Mr. J. Z. Davis lost no time in purchasing the bodies, and generously presented them to the State Mining Bureau, where they form one of the many notable attractions that are daily viewed by hundreds.

Aside from their great curiosity, as being among the first natural mummifications discovered on this coast, these well preserved human remains present a great many points of general and scientific interest.

These naturally mummified bodies differ from mummies proper, in the general acceptation of the term, inasmuch as no embalming process for their preservation was used. They were desiccated in their cave sepulcher by the natural elements. The dry, hot atmosphere extracted all the moisture from the tissues, and the bodies literally dried up as we would dry jerk beef, or as the Indians of to-day dry the bison (buffalo) meat, which keeps for years.

There is no evidence of these bodies having undergone any preparatory process. The brain, heart, lungs, abdominal and pelvic viscera are all intact and dried to a solid consistency,

The larger mummy represents the powerful frame of a male body, about five feet eight inches tall and well proportioned. The bones are large, and he must have had an excellent physique. He probably weighed between one hundred and eighty and two hundred pounds. All the body now weighs is fourteen pounds!

The integument is well preserved, and presents the appearance of dried hide, or thick parchment, of a dark gray color, and all that remains between it and the bones are the dried muscles, tendons, nerves, and fascia. The body is well developed, the shoulders measuring from one acromion process to the other three hundred and ninety millimeters (about fifteen and a half inches); the hands are small, and the fingers tapering; the feet are also small, measuring two hundred and forty millimeters (about nine and a half inches), and highly arched. The phalanges of the digits are perfect, each having the normal number of bones, and the ungual appendages are well preserved and not unusually long.

The body has dried in the sitting posture, hands crossed and knees drawn toward the chin. It will be observed that the cheek and lips on the left side protrude. This probably occurred during the time of mummification; the moisture leaking from the interior of the brain and surrounding tissues, through the cribriform plate of the ethmoid at the anterior portion of the calvaria, through the cribriform foramina into the inferior meatus nasi, and the head being inclined toward the left, produced this bulging from the force of gravitation. Being itself in turn dried up, the mouth maintained its present shape. Short, stiff hairs can be seen on the head. The eyebrows and eyelashes are also distinctly visible. A little hair can also be noticed on the upper lip, but very little beard anywhere on the face. The ears are closely pressed against the sides of the head and only the cartilages remain. The eyes are quite perfect, and present a slight outward obliquity. The nose, originally broad, has been more flattened by the shrinking of the cartilages and the alae nasi. The lips are stiff and solid and the tongue is shriveled to the consistency of cork. There is a full set of masticators in his mouth, thirty-two in number, and all quite well preserved. A few of the dentures only have the enamel worn down to the dentine. The ribs are large and well formed, indicative of a well shaped chest. The genitalia are well preserved.

It will be observed that on the head there has been a large growth of hair, on the face very little, and on the body scarcely any at all.

CRANIAL MEASUREMENTS.

Owing to the dried integument and fascia covering the cranium, accurate measurements of the skull are well nigh impossible. The following measurements, however, have been made with as much care and accuracy as the subject permitted. The cranial measurements are as follows:

Circumference, 530 millimeters; length, occipito-frontal, 178 mm.; breadth, bi-bregmatic, 140 mm.; breadth of frontal, 108 mm.; height, 135 mm.; facial angle, 71°.

The sutures and wormian bones cannot be inspected. The malar bones are quite prominent, and the lower maxillary and face may be classified with the group orthognathous.

A careful study of this mesocephalic head would indicate that its possessor was of more than average intelligence. The perceptives are well developed. And, although the animal passions undoubtedly predominate, there is enough veneration or religion to class it among the scaphocephalic skulls.

The next mummy represents all that is earthly of what was once a woman and a mother. She is in a better state of preservation than the preceding body. From a measurement of the individual bones, she would be about five feet five inches tall, and weighed, perhaps, about one hundred and fifty to one hundred and seventy pounds. The body weighs, in its present condition, only twelve pounds! The posture, integument, body, etc., resemble the one previously described. A rare chance is here given for the examination of the internal organs, owing to an absence of integument on the major portion of the right side. The lungs resemble a dried sponge in appearance, and the heart looks like a dried piece of meat. The great blood vessels and the abdominal and pelvic viscera can be explored, and with the exception of being all shriveled up, there is no anomaly, either in position or arrangement. The large, oval pelvis and the once well developed mammæ bear unmistakable evidence of gestation. The hands and feet are small and well shaped; the foot measuring only two hundred and fifteen millimeters (about eight and one-half inches). On the head will be seen a luxuriant growth of hair, which centuries have not yet succeeded in destroying. It is very fine in texture, of a dark brown color, and entirely unlike any Indian hair seen to-day. A curious feature is observed in connection with the small, well proportioned ears, both of which are perfectly preserved, and that is in each lobe is worn, even in the stillness of death, a piece of hollow bamboo or reed, about forty millimeters in length and ten millimeters in diameter. This was likely considered an ornament in her day. Our Indians of to-day pierce the helix and anti-helix of the ear, through which holes they suspend ornaments of different kinds. The single perforation in the lobe of this mummified woman's ear would indicate a custom observed by her people, similar to the customs in vogue in the more civilized countries, and are not usually observed by Indians of our own period.

The windows of the soul, although now sightless and dim, are singularly perfect, presenting a slightly outward and upward obliquity of the external canthi.

The nose is also quite perfect, and inclined to be rather broad and flat than thin and projecting. The malar bones are very prominent, the lips thin and stiff, and the tongue dried and solid. Two central incisores and one canine of the superior maxillary are gone, and several other teeth are badly caried.

Here, again, the same difficulty of hair and dried integument prevent absolutely accurate cranial measurements. The skull measures: Circumference, 508 millimeters; length, occipito-frontal, 166 mm.; breadth, bi-bregmatic, 128 mm.; breadth of frontal, 108 mm.; height, 132 mm.; facial angle, 69°.

This skull presents a large forehead and well developed reasoning powers. The woman was likely filled with noble instincts and motherly kindness. It is very rare to find so good a head among Indian women of to-day.

Next is the mummified remains of a little boy about seven years old. The little fellow had been enveloped in his burial shrouds the same as the larger bodies—hands crossed on the chest, knees doubled on the breast, and the head inclined forward. All the bodies were likely tied in this position when placed in the cave. The body is about three feet tall, and weighs now only three pounds! The same general characteristics as to skin, tissues, bones, etc., that were observed in the preceding bodies may also be seen here. The head is well developed for a boy of his age. The hair has been broken off near the scalp. Only the cartilagenous parts of the ears remain. There is the same contour of face—flat nose, high cheek bones, outward obliquity of the eyes, etc. The upper and lower incisores and canine of the temporary or milk teeth are gone, and the permanent set coming at their roots in the alveolar processes.

The two anterior molars of the superior maxillary are just appearing through the alveolar processes, establishing the age with tolerable accuracy at about seven years.

In circumference the skull measures 440 millimeters; length, occipito-frontal, 146 mm.; breadth, bi-bregmatic, 120 mm.; breadth of frontal, 60 mm.; height, 114 mm.; facial angle, 71°.

Considerable of his burial shrouds remain about the body yet. The major portion of it is cotton fabric, firmly secured around the body by a stronger cord, made of braided hair.

Next we have all that is earthly of a little girl, about fourteen to eighteen months of age. She weighs only a pound and a half!

The little one has been enveloped in an animal's skin, the better to protect its tender frame. Both feet are gone, and the tibiæ and fibulæ protrude through the skin. The four upper and four lower incisores, with the corresponding canine teeth, have made their appearance, showing the child to be about fourteen to eighteen months old. Otherwise the same features are noticeable in this as in the preceding figures.

It would appear that the group of four belong to one family, and that they were buried by friends, and hermetically sealed in this cave for fear of some real or imaginary foe. It may have been at the time of the Spanish invasion, or it may have been during the warlike times anterior to this date, when the Aztec confederation was warring with the Toltec people.

From their physical and mental developments the race seems to have been a superior one.

The facial features observed in these bodies are not those we find in that locality now. The cranial configurations and physical appearances would rather favor Aztec lineaments than those of our Indian of to-day. The fine dark brown hair is certainly not Indian, nor do the small hands and feet bear much resemblance to the huge hands and feet we see on the Indians now living. It is not desired to be understood that a race or classification can be even approximately established by the measurements of a few crania; for it cannot. It only aids us in determining that particular individual's peculiarities. Too many ethnological classifications have been advanced on the measurements of a few skulls and on the descriptions of a few bodies. Measure, for example, a few skulls of any race, and see how much they differ in the very essentials of capacity, circumference, length, breadth, height, facial angle, etc., that go far in the classification of ethnologists. We may draw attention to the similarity existing between these bodies and the Asiatics, for instance, but we cannot *a priori* establish a relationship, nor can we positively determine from our present data that these bodies are Toltecs or Aztecs, however much our own views may favor such a theory.

The fabrics found on the bodies, forming the burial shrouds, are chiefly composed of cotton, hair, hide, grasses, and the bark of willows. The cotton is twisted and coarsely woven, each thread being from a half to one millimeter in diameter. The hair is treated in like manner occasionally, although usually it is braided with three or four divisions in each cord. Frequently we find strong strands made of strips of hide covered with willow bark.

Although the weaving of this interesting people is that known as the "plain" process, that is, where the weft passes alternately under and over the threads of the warp, producing more or less open mesh cloth, yet considerable skill and ingenuity were observed in the manufacturing of their blankets, mats, and ornamental cloths, which were frequently interwoven with beads and colored threads, presenting various designs. Grasses and straws were also woven into mats and cloths, which were of great durability. The skins of animals were also used for clothing purposes.

OBSERVATIONS ON THE INFANCY OF THE INTELLECTUAL RACES.

The origin of the human family has ever been shrouded in the deepest of mysteries. Scholars of the first eminence have given to the world the results of their researches, but, unfortunately, no two of them are agreed. We may accept any one of the three prominent hypotheses, each one of which has been so ably advocated from the days of Camper and Blumenbach down to our own time.

The first or special creation theory is that of the monogenists. It teaches that Adam and Eve were created in the alluvial valleys of Asia, and brings to its aid the records of holy writ. Many of the most renowned ethnologists and thinkers of the age support this hypothesis. Anatomically considered, there is no difference between a Caucasian and an Ethiopian, or a Caucasian and an Indian, except, perhaps, the contour of the skull and face, stature, etc. Bone for bone, however, they are anatomically alike. It is observed that climate, habits, etc., account largely for the difference in the color of the skin, texture of the hair, etc., and true it is, a vine grown in the dark is found to be translucent, and almost colorless. Likewise the bear is white in the Arctic region, brown in the temperate, and black at the equator, although anatomically allied.

Man, unlike animals, the monogenists claim, is a direct issue of the creative or divine power, and that the Hebraic record is the only solution of the origin of things.

The polygenistic or second theory of the creation of man teaches us that there was not only *one*, but that there were *several* special creations, one for each race, and that climatic surroundings do not account for all the diversities and differences found in the human race. The learned ethnological authorities advocating the polygenistic theory argue that the Mosaic account is true, but that it only includes the history of one race. These authorities, although directly antagonistic in many of their views, must be received with due respect, owing to the distinguished positions they have earned in the many branches of anthropology.

During the last fifty or hundred years these two prominent theories have not materially changed.

The third hypothesis, that of evolution, is of more recent birth, and although it may be more repugnant to the *quasi*-scientific mind, it is nevertheless truly scientific. We are all more or less familiar with the evolution of life as witnessed in the infusorial animalcules in water, spores in the air, generation of fungi in cereals, and birth, as it were, rising out of death. In a few hours a decayed cabbage head or a putrescent piece of meat, under favorable conditions of temperature and moisture, will teem with new life. It is not desired to be understood that an extreme view of evolution is advocated, or even implied, for it is not believed possible to evolve, generate, or create organic life in the laboratory out of inorganic elements. The egg whose germinal vesicle has not been fertilized by the male bird cannot bring forth a chick, nor can inorganic atoms bring forth organic life.

Through countless ages, natural selection, the survival of the fittest, continual advancement, development, and improvement have at last evolved man in his present condition. The human species has reached its ultimatum of physical perfection. The *fixity of type* is stamped on the human embryo long before it is discoverable by man. Naturalists point out the anatomical similarity between man and beast. In his embryonic state man cannot be differentiated from the wolf or the horse by the most powerful microscope or by the most delicate analysis. The germs of the embryos of the tortoise at the fourth week, the chick at the fourth day, the dog at the fourth week, and man at the fourth week, are alike insusceptible of differential demonstration. Physiologically and chemically they are identical. Indeed, bold thinkers of the present day assert that man is not a biped, and that his natural mode of locomotion is on four instead of on two limbs. The *foramen magnum* would certainly indicate that the head was originally in a horizontal relation to the vertebræ, and the sacrum and coccyx bear a strong resemblance to the caudal extremity in animals.

ETHNOLOGICAL CLASSIFICATIONS.

On the next stepping stone—ethnology, or the science which treats of the classification or races of man—we find monogenists, polygenists, and evolutionists again trying to unite their forces in analyzing and classifying humanity.

Thus we find that Virey gives only two races of men on the globe. Cuvier makes three. Linnæus increases them to four. The great Blumenbach issues five, Buffon six, Peschel seven, and the renowned Agassiz eight different races. Pickering comes with eleven, and the learned Fredrich Muller assures us that there are twelve. Bory de St. Vincent sees fifteen. America's greatest anthropologist, Morton, increases the number to twenty-two, while Crawford has sixty and Burke sixty-three special creations. These classifiers represent the highest authority of which the world can boast, men who have devoted their lives and powerful intellects to the intricate problem. Doubtless they would all agree had they adopted the same standard of comparison, but one distinguishes a race by geographical location; another by language, habits, and mental traits; another by stature, contour of skull and face; another proposes the color of the skin, and still another the texture of the hair; while the most acute observers combine all the distinctions and characteristics, and still they give us from *two* to *sixty different* human races.

Adopting whatever classification you may, and accepting whichever theory of creation you will, we can almost admit that there is not as much difference between the higher forms of apes and the lower forms of savages as there is known to exist between the highest and the lowest forms of humanity, when we look at the races existing to-day on nearly all parts of the globe.

If the poor, miserable savages are not actually below the brute creation, they are certainly not very far above it. Look at the Fuegian, for instance, crawling from the lair in which he lies, coiled up like an animal on the wet ground, to gather the food on which he subsists, mussels and berries, whenever hunger demands it. On state occasions they vary their bill of fare by killing and eating their old women. Their language is an inarticulate clacking. The negroes of New Guinea live on the trees, and spring from branch to branch, like monkeys, gesticulating, screaming, and laughing, and eke out their living on the indigenous fruits, as do the apes themselves. The Alforese of Ceram also live in trees, like the birds, each family being in perpetual hostility with every other family, human and animal. The forest tribes of Malacca communicate by means of noises very similar to the native birds. Again, the Dyaks hunt and kill the wild people of Borneo as if they were monkeys. The cannibal Fans of equatorial Africa bury their corpses for several days before they eat them.

In Chinese cities rats are sold at fifty cents per dozen for the table. The hind quarters of the dog command a higher price than those of lamb or mutton. In Brazil ants are eaten alive with resinous and spicy sauces. In Africa they are stewed in grease. The East Indians catch the ants in pits and wash them in handfuls, and eat them. One of the most costly dishes in Siam is a curry made of ants' eggs. Shrimps are eaten alive by the Sandwich Islanders. The Singalese eat the bees after robbing them of their honey.

The negroes of the West Indies eat baked snakes and worms fried in fat. In the Pacific Islands lizards and their eggs are considered wholesome. Roasted spiders are used for dessert by the New Caledonians.

A pygmy race in South Abyssinia, the Dokos, grow their nails like the talons of the vulture to enable them to dig up ants and tear in pieces the flesh of serpents, both delicacies which they eat raw. Almost any animal compares favorably with the fierce Bosjesman, whose diet is composed of worms, beetles, and pismires, unless he can share with the hyena the putrid carcass of a buffalo or an antelope. A gibberish speech, like the growling of a mad dog, is the language of the Yamparico, who lives on roots, crickets, and different species of bugs. The aborigines of Victoria live on roots, grubs, mushrooms, and frogs, with an occasional feast in the shape of a new-born baby, killed, roasted, and eaten by the parents and friends. The locust plague on the Pacific coast in 1875, sent by the Great Spirit, was a source of worshipful thanksgiving to the Digger Indiads, who dug large pits, swarmed them full of locusts, which they killed, dried, and ground to powder in their stone mortars, and thus laid in a store of food which lasted them for several years.

The Russians use the fermented liquid of cabbage for their beverage. It is called "quass," and may be described as resembling in taste a mixture of stale fish washed in soapsuds; and next to beer, more civilized (?) people drink it than any other beverage.

After they have wound the silk from the cocoon, the Chinese eat the chrysalis of the silkworm. In Mexico, parrots are eaten; and in the Argentine Republic, skunks are much sought after for the table. The African bushmen are very fond of spiders, and caterpillars are very dainty and costly.

The most ghastly ornamentation I have known is worn by the houseless, mischievous, and vindictive Andamer; it consists of a row of skulls, worn around the naked necks of this form of humanity. The Bannaks wear lumps of fat meat, artistically suspended from the cartilages of the nose.

It seems, indeed, hard for us to look back upon our ancestors as a miserable anthropophagous population, maintaining an inglorious struggle with the powers of nature, wrestling with naked bodies against the forest animals, and frequently forced to dispute their cave dwellings with the hyena and the wolf, and yet we have but to look at the leather-skinned Hottentot, whose hair grows in short tufts, with bare scalp between, and is only a creature of passions, feelings, and appetites.

Look at the wild people of Borneo; the Negrillos of Armanga; the Battas of Sumatra; the hairy Ainos of Jesso; the Hyglous of the White Nile; the aborigines of India; and even the Cagots and other mandities of France and Spain. These species—and we must call them human—with squalid habits, ugly and deformed heads, hideous aspect, and prognathous faces, have probably lived as long, and perhaps longer, than the Caucasians; and, as Darwin observes, they are supposed to enjoy a sufficient share of happiness and comfort (of whatever kind it may be) to render life worth having.

Many races on different parts of the globe attribute their origin, not to the gods or demigods, not even to lions, as do the Sahos, or to goats, as do the Dagalis, not to the sun or moon, as do many of the Pacific coast tribes, but to *apes*. This has been the cherished belief for ages among the Miautsee or aborigines of China, a country whose boasts of creation antedate ours by many thousands of years. The Thibetans and many African tribes also lay claim to the ape as a forefather.

While not advocating evolution *per se*, we are almost forced to admit its possibility on purely scientific grounds, even to the extent of evolving man through the countless ages of the earth's existence, out of—not inorganic atoms or molecules, but out of flesh and blood, by the aid of the all-wise creative power. As Professor Le Conte says: "I believe that the spirit of man was developed out of the *anima* or conscious spirit of animals, and that this, again, was developed out of lowest forms of life forces, and this in turn out of the chemical and physical forces of nature; and that at certain stages in this gradual development, viz., with man, it acquired the property of immortality precisely as it now, in the individual history of each man at a certain stage, acquires the capacity of abstract thought."

The following striking example shows what can be done in *one* generation in the way of transforming a land animal into one capable of living entirely in water. By taking the embryo of the land salamander out of its egg and keeping it in water at a moderate temperature, abundantly supplied with oxygen, and amply fed with small living water animals, its organism will change. The embryo inhales the oxygen held between the molecules of water, and not the atmosphere, like its parents, breathing with lungs. The embryonic lungs therefore remain undeveloped, but, by way of compensation, small gills will appear on each side of its head. This function of breathing by the gills will gradually increase as the body grows. Feeling the necessity to swim and not to creep, as do its land parents, the four extremities become mere rudimentary appendages, while, on the other hand, a vigorous rudder tail develops. The new function of swimming calls forth fins, and the animal actually develops new organs which the parents did not possess. This is a simple experiment which can be accomplished by any one with a little trouble. Thus we find substantially a new animal is produced which elsewhere does not exist. This proves that new organs and new functions are developed when necessary to the individual's existence; in other words, evolution, pure and simple.

There is nothing incompatible or inconsistent in such a view with the Mosaic records; and I am proud to say that the days of theological narrow-mindedness and denunciation of scientific truths are happily disappearing, and seeking as true an investigating channel as does the snow on the mountain side under the influence of the sun's rays seek the proper channel for its sparkling waters.

The three great bishops of the Church of England (1887) are the pioneers in this noble line of inquiry—development (evolution). An extract from one will suffice: ". . . And to what are we indebted for that potent word, which, as the wand of a magician, has at the same moment so completely transformed our knowledge, and dispelled our difficulties? To modern science, resolutely pursuing its search for truth, in spite of popular obloquy, and—alas! that one should have to say it—in spite, too, often of theological denunciation." (*Bishop of Manchester.*)

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN
Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

MUNN & CO., Publishers,
361 Broadway, New York.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. CHEMISTRY.—The Atomic Weight of Zinc as Determined by the Composition of the Oxide.—By H. N. MORSE and W. M. BURTON.—A full account of methods and manipulations for this determination, remarkable for their simplicity and accuracy.—3 illustrations 13560

II. CIVIL ENGINEERING.—Perekop Canal.—The new work to connect the Crimean Peninsula with the main portions of Russia..... 13560
The Improvement of New York Harbor.—An account of the dredging operations now in progress, and the probable outcome of the work.—5 illustrations 13560

III. ETHNOLOGY.—The Californian Mummies.—By WINSLOW ANDERSON, M.D.—A detailed account of the mummies recently found in the Sierra Madre Mountains, California, and of their relations to existing races.. 13563

IV. GEOLOGY.—Geology.—By ARCHIBALD GEIKIE.—The subject of igneous rocks considered.—Lava and trap, and the agencies of their formation.—8 illustrations..... 13567
Mineral Resources of the United States—Calendar Year 1887.—A summary of the work of the U. S. Dept. of the Interior, including a review of the geological wealth and production of this country during the past year.. 13560

V. MECHANICAL ENGINEERING.—New Post Office Building, Paris.—The system of elevators used in the new post office in Paris illustrated and described, with elevation of the building.—3 illustrations..... 13563
The Prall System of Distributing Heat and Power from Central Stations.—By E. D. MEIER.—A system of distribution of hot water under high pressure, and its practical test and operation in Boston..... 13563
Warner' Hay and Straw Press.—A steel framed screw press of great power and simplicity of construction.—1 illustration..... 13563

VI. MISCELLANEOUS.—Preparation for Speech Making.—A most graphic and practical paper advocating preparation for oratorical efforts, with accounts of great speakers and their methods..... 13563

VII. NAVAL ENGINEERING AND TACTICS.—The Defeat of the Armada in 1588.—A vivid account of the naval battle just celebrated in England, with personal notes, and accounts of the ships.—3 illustrations 13563
The French Mediterranean Squadron.—One of the phases of the recent maneuvers described and illustrated, fighting with machine guns in the main top of a man of war.—1 illustration..... 13563

VIII. ORDNANCE AND FORTIFICATION.—French Disappearing Turrets.—The new system of fortification, offering almost absolute security to the occupants, how the plates are tempered, and the full description of the mechanical arrangements.—2 illustrations.. 13563

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.

88.

ent.

in any
have a

om the
Price,

n like-
yearly,
$0.50

AMER-
UPPLE-

s, and

N. Y.

PASS
the
OX.
mi-
tra-
.... 1865
con-
.... 1865
the
e of
.... 1865
AN-
and
ons
.... 1865
t of
e of
.... 1865
—A
ding
tery
.... 1865
ing,
e in
y.—9
.... 1865
tral
ster
ion-
.... 1865
the
.... 1865
ring
ute
the
ns.. 1865

oks

ginees,
ssional
of their
ermits
at very
books
nt sub-
lation,
d, with
re only
ress,

York.

rican,
an and
ce, and
world.

meri-
gency,
By the
tion le
ales or

inven-
patents
& Co.
Patent
ts, and

ork.